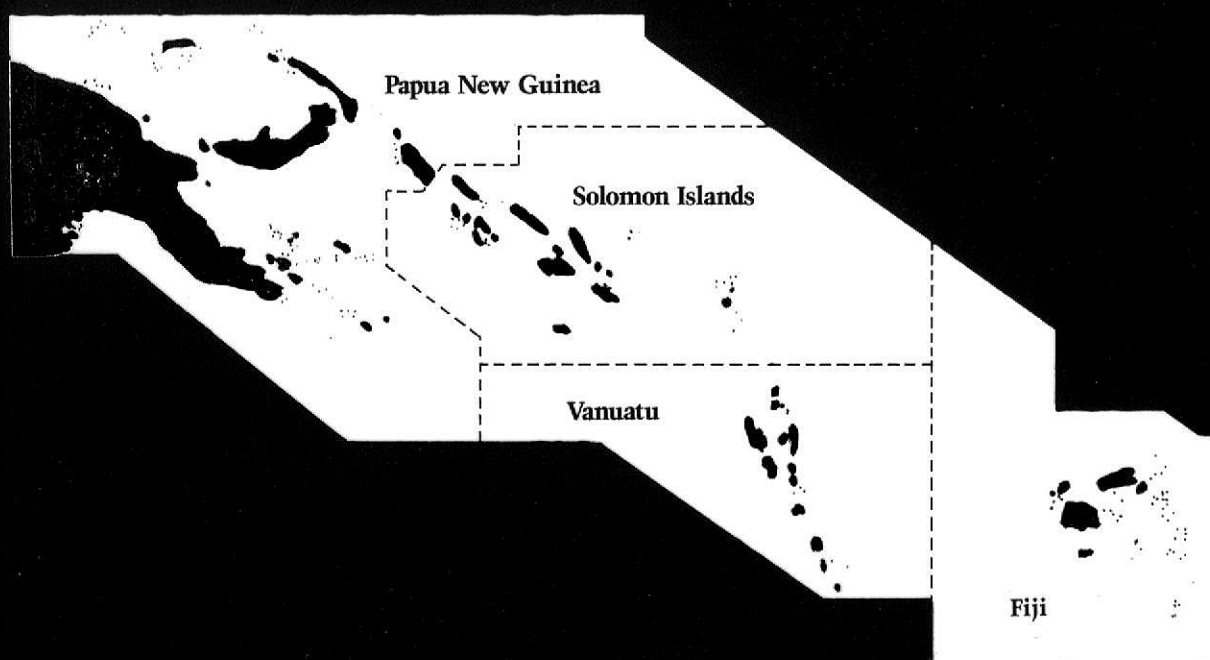


GOLD POTENTIAL SOUTHWEST PACIFIC



PAPUA NEW GUINEA
SOLOMON ISLANDS
VANUATU
FIJI



EAST-WEST CENTER, HONOLULU, HAWAII



Nguzu Nguzu, New Georgia

GOLD POTENTIAL OF THE SOUTHWEST PACIFIC

**PAPUA NEW GUINEA
SOLOMON ISLANDS
VANUATU
FIJI**

J.A. Lum
A.L. Clark
P.J. Coleman





Foreword

Gold Potential —

Papua New Guinea - Solomon Islands - Vanuatu - Fiji

Ideas on the genesis and modes of emplacement of gold-bearing bodies have undergone enlightening changes over the last few years. The implications for gold discoveries in such islands and island chains as Papua New Guinea, Solomon Islands, Vanuatu and Fiji are far-reaching. They are discussed in this review, together with the potential for gold discovery in these countries of the Southwest Pacific region. The host countries and farsighted entrepreneurial companies both stand to benefit from the intelligent and restrained but vigorous development of gold resources. The East-West Center's Pacific Islands Development Program, the research and training arm of the Pacific Islands Conference of Leaders, is glad to support this review. It fits squarely into the PIDP Minerals (Gold) Project, with its emphasis on mutual benefit and ensuing development.

Sitiveni Halapua

Director, Pacific Islands Development Program,
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July, 1991



Nuggets, Mt Kare

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Pacific Islands Development Program

Minerals Policy Program

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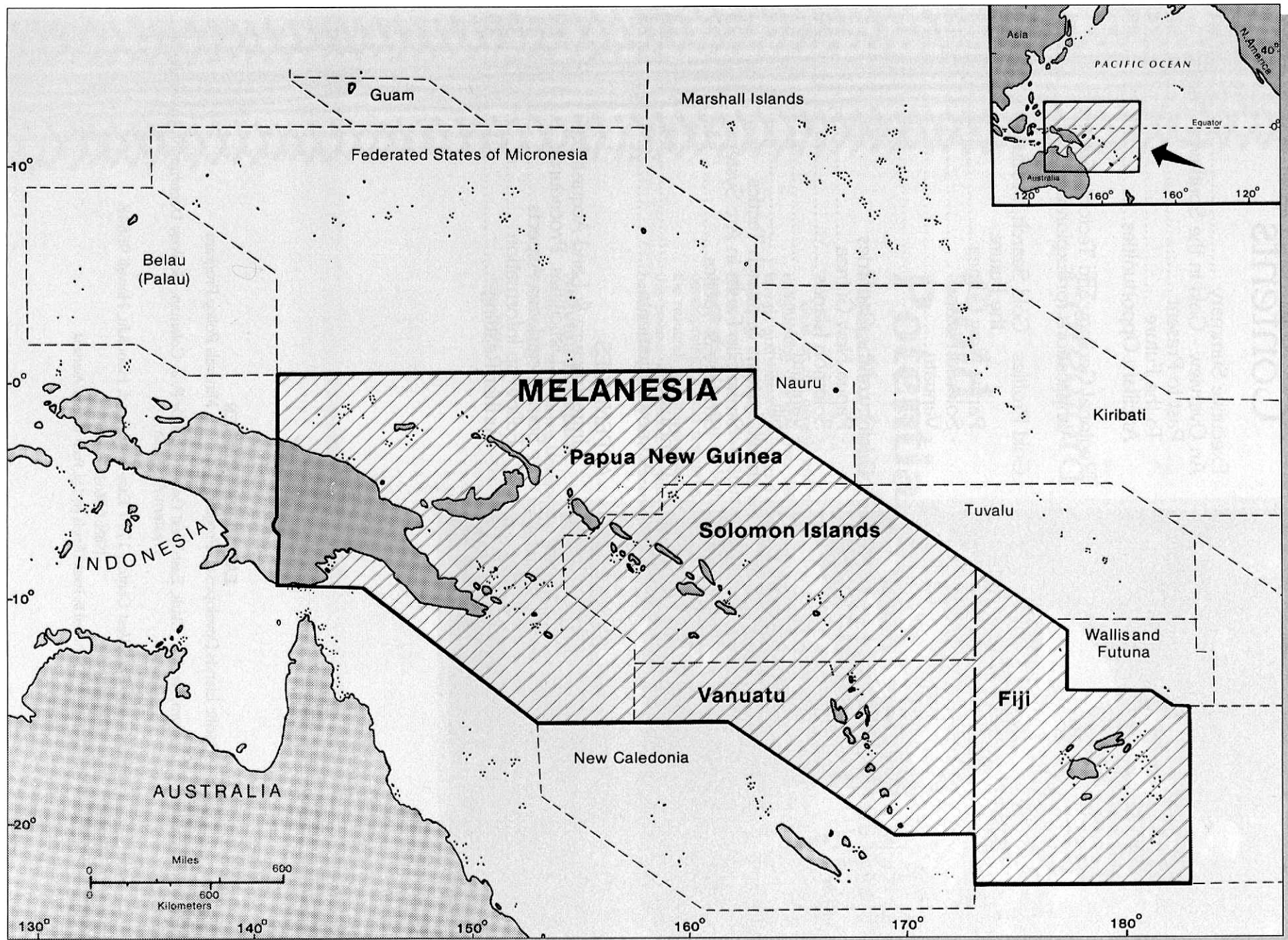


Figure 1. Papua New Guinea, Solomon Islands, Vanuatu, Fiji.

Executive Summary

The recent exciting discoveries of substantial deposits of gold and associated metals in Papua New Guinea highlight the excellent gold potential of the entire region of the Outer Melanesian arc systems in the Southwest Pacific — central and northern Papua New Guinea, Solomon Islands, Vanuatu, Fiji (Figure opposite). Twenty two major gold deposits, most of them newly discovered, are scattered through the region (Figure 2). The region's excellent potential springs not only from the recent discoveries and the similar geological evolution of the component countries, but also because new concepts on the tectonics and structure of arc terranes suggests that epithermal and other large-scale convective hydrothermal systems are a normal part of the growth of a generalized arc body (including backarc extensional basins). This applies especially to the stage following on the development of calcalkaline magmas. As well, empirical observations indicate that high-level intrusions, and their associated hydrothermal systems, tend to be rich in ore metals if the intrusions have penetrated complex crust, with a complex structural and geomorphological history, such as that possessed by much of the Outer Melanesian arc system.

The success rate in the search for hydrothermal systems in arc terranes has increased over the last ten or so years but probably still falls short of the actual incidence. A relatively low discovery pattern may well reflect inadequate search tactics, especially the failure to recognize the almost ubiquitous presence of deeply penetrating strike-slip fault movements and the consequences of this style of fault action. Translational movement between fault blocks can lead to extensive block rotations with the distortion of the outcrop pattern of high level intrusions, and also to extremely rapid vertical block movements. Explorers may not appreciate the rapidity with which the outcropping part of a hydrothermal deposit can be covered physically by young, superficial sediments, shed from adjacent uplifted highs. As a result, the deposit is masked to routine exploration endeavours.

High-level intrusions are facilitated by transtensional situations that occur along active strike-slip faults, as developed in the model presented later on (Fault Systems...). Because of the undulating nature of the fault plane, such

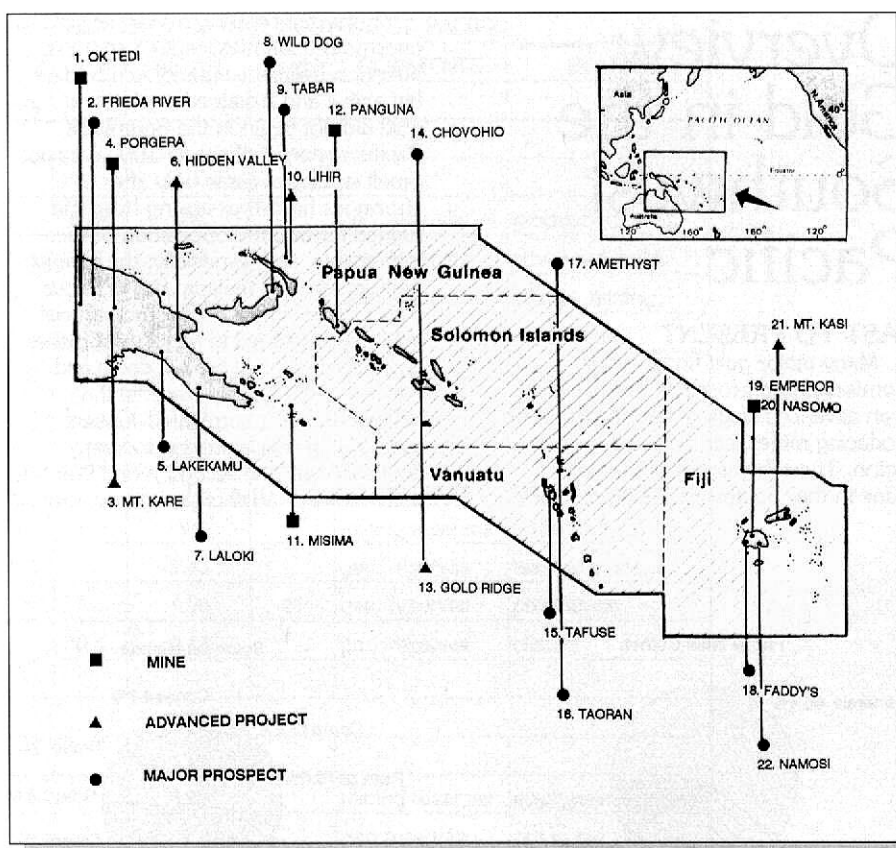


Figure 2. Mines, Projects, Prospects

transtensional pathways may go to great depth. Their role as access channels is enhanced when they coincide with faults conjugate to a major strike-slip fault or are intersected by other deep faults such as those orthogonal to the arc system.

A search for these high level intrusions should include a thorough analysis of the fault patterns in the target region, with special emphasis on the presence of strike-slip faulting. The delineation of fault block complexes should be supplemented by sophisticated high-sensitivity airborne magnetic and radiometric surveys.

Of the four countries dealt with here, Papua New Guinea has the most impressive record of new gold discoveries over the last decade. Even so, its territory is large, much of it made up of a complex of arc systems, and so, despite the record of recent discoveries, the country remains incompletely explored and still full of promise. The other countries, with the possible exception of Fiji, are even less well known. As with Papua New Guinea, their governments also favour intelligent exploration and development. The legislative aspects governing exploration and development are generally fair and reasonable. The large problem of land access in communities that look on land as a part of their communal heritage is difficult, but can usually be overcome

with a sympathetic and understanding approach.

In brief, for the region covering the Outer Melanesian arcs, including Papua New Guinea, Solomon Islands, Vanuatu, Fiji, we propose that opportunities for gold discovery are high. In essence, our proposal is based on these items: 1) the increase in significant discoveries; 2) the similarity in all four countries of rock systems developed as Tertiary arc terranes; 3) the tendency for known deposits to be geologically young, Late Miocene-Pliocene; 4) the relatively low level of exploration intensity, coupled with 5) failure to sense the importance of large-scale fault control as modelled herein.

For the countries of the Outer Melanesian arcs and their gold potential, the 1990s are a promising decade. The reason for this review has its roots in this promise and the role of the review is to show why.

Overview — Gold in the Southwest Pacific

PAST TO PRESENT

Many major gold finds, either promising large prospects, or prospects at an advanced stage of development, or producing mines, can be listed for the region. These highlights of the gold scene in the Southwest Pacific, as

In the last century, rumors of gold in enormous quantities inspired sporadic attention from adventurers and traders but active and sustained exploration for gold did not begin in the Southwest Pacific region until nearly 100 years ago. Small successes came only after enormous hardships arising from the rugged terrain, the opposition of the inhabitants, and, especially, the ravages of dysentery and malaria. But in Papua New Guinea, in the 1920s, rich alluvial gold discoveries led to minor gold rushes. Giant dredges were broken down and flown inland, piece by piece, in the famous tri-motor corrugated Junkers aircraft. An alluvial mining industry flourished until the second World War but then declined. Well-organized exploration

Fiji. Several large gold deposits were discovered (Lum, 1990). The Ladolam deposit, on Lihir Island, off the north coast of New Ireland (and geologically part of the Solomons) is just one of these, a grass roots discovery with gold reserves estimated at 19 million ozs. The Porgera deposit, central Papua New Guinea, is another, first discovered in 1938 and considered to be a minor prospect then re-evaluated in 1989. Porgera contains about 9 million oz of recoverable gold, valued at about US\$3 billion, and has now begun production.

In Solomon Islands, Gold Ridge, in Central Guadalcanal, is a potentially rich deposit and a mining lease to start mine development has been requested by the company concerned. In Fiji, the

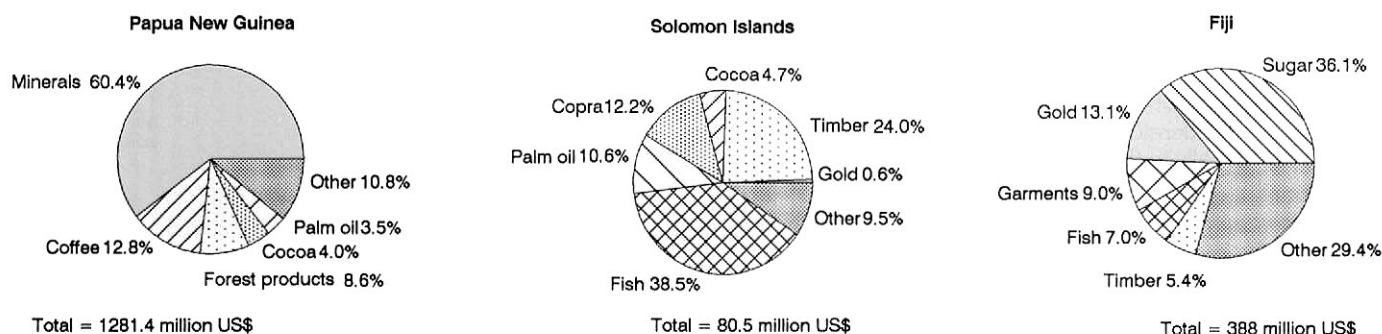


Figure 3. 1988 - Principal Export Earnings of Papua New Guinea, Solomon Islands, Fiji

shown in Figure 2, supported by Table 1, are supplemented by many other smaller or less well-known targets (e.g., Clark & Lum, 1990). They are being probed at varying levels of intensity (the level usually being dependent on the cash resources of the investigating company). All of these discoveries are important in themselves but they are also indicative of the gold potential of the region.

A belief in this potential has been held in at least shadowy form for a very long time indeed. As long ago as 1528, the name "Isla de Oro" was given to the island we now know as New Guinea by the Spanish explorer Alvaro de Saavedra (Sharp 1960), a name based on wishful fancy rather than observation. The Solomon Islands archipelago was named after the great King Solomon (and his riches!) by Alvaro de Mendana, following his discovery of the islands in 1568; he searched for, and reputedly found traces of gold. Not long after, De Quiros had expectations of gold in Espiritu Santo, Vanuatu. In Fiji, gold was first reported in 1868.

by a few determined companies began after the war.

International attention was attracted by the opening in 1972, by CRA (Australia), of the giant porphyry copper mine, at Panguna, on Bougainville Island, Papua New Guinea. Exploration became more intense and systematic. Another porphyry copper mine, Ok Tedi, in extremely rugged and remote country in western Papua New Guinea, became a producer in 1984, at a cost of over a billion Australian dollars. Ok Tedi, with Bougainville, made Papua New Guinea a significant copper and gold producer, ranking ninth in the world. Today, Ok Tedi is still an extremely large gold producer.

As gold increased in price, emphasis shifted to exploration for epithermal deposits. A boom period followed, with the creation of many entrepreneurial companies, based mainly in Australia, some of which, unfortunately, were more speculative in intention than exploratory. Nearly all available ground was taken up in Papua New Guinea, Solomon Islands, Vanuatu and

Emperor Mine at Vatukoula on Viti Levu is an operating mine that started production in 1935 and is expected to continue to produce some 130,000 oz of gold per year. The Nasomo deposit is nearby, with an estimated 300,000 tonnes of ore at 14g/t gold. In Vanuatu, active exploration has lagged somewhat, but promising prospects on Espiritu Santo, Malekula and Efate have been recorded.

The emphasis here is on deposits of hydrothermal origin. Gold-bearing volcanic massive sulphides appear to be rare in the Southwest Pacific countries, although in Papua New Guinea there are large areas of ocean floor rocks, as also, but to a lesser degree, in the Solomons, and Vanuatu. In Fiji, there are known massive sulphide deposits containing some gold. Another field of potential is that which covers nearshore marine and coastal environments as a source of secondary gold. This potential is real but has not been explored as yet.

Mining is the second most important sector after agriculture in both Papua New Guinea and Fiji (see Figure 3). In

MAJOR MINERAL DEPOSITS OF THE SOUTHWEST PACIFIC							
	DEPOSIT NAME	TONNAGE	Cu %	Au g/t	Ag g/t	COMMENTS	STATUS
		M tonnes					
PAPUA NEW GUINEA							
1	OK TEDI	300	0.75	0.6		geo. reserves	production
2	FRIEDA RIVER	592	0.5	0.34		geo. reserves	advanced expl.
3	MT. KARE	2 m3		7.5 g/m3		geo. reserves	alluvial mining
4	PORGERA	85.8		5.7	11.9	geo. reserves	production
5	LAKEKAMU	27.7 m3		154 mg/m3		geo. reserves	advanced expl.
6	HIDDEN VALLEY	47.5		1.63	24	geo. reserves	feasibility stage
7	LALOKI	0.37	3.93	3.75	10.76	geo. reserves	advanced expl.
8	WILD DOG	0.65		7		geo. reserves	advanced expl.
9	TABAR	0.695		4.2		mining reserves	advanced expl.
10	LIHIR	167		3.43		geo. reserves	feasibility stage
11	MISIMA	56		1.38	21	geo. reserves	production
12	PANGUNA	530	0.4	0.46		geo. reserves	closed
SOLOMON ISLANDS							
13	GOLD RIDGE	1.34		3.86		mining reserves	await govt .approv.
14	CHOVOHIO	20 m3		0.3 - 2 g/m3		geo.reserves	out to bid
VANUATU							
15	TAFUSE	not evaluated					grassroots expl.
16	TAORAN	not evaluated					grassroots expl.
17	AMETHYST	not evaluated					grassroots expl.
FIJI							
18	FADDY'S	2		2		geo. reserves	advanced expl.
19	EMPEROR	1.2		6.4		mining reserves	production
20	NASOMO	0.3		14		mining reserves	production
21	MT. KASI	0.5		6		geo. reserves	advanced expl.
22	NAMOSI	500	0.49	0.16		geo. reserves	prefeasibility stage

Table 1 - Major mineral deposits- New Guinea, Solomon Islands, Vanuatu, Fiji.



Papua New Guinea, export receipts from mining in 1989 were some US\$773 million, 60% of the total principal exports (\$370 million for gold, \$403 million for copper). Mining and quarrying contributed 18.2% of the total GDP in 1989. In Fiji, for 1989, export receipts for mining were US\$51 million, about 13% of the total export earnings (Figure 3). Although the mineral sector of Solomon Islands currently contributes only about 1% of the country's export earnings, with the development of the Gold Ridge mine on Guadalcanal, this figure is expected to jump significantly so that mining will become the third largest export earner, after fish and timber, in 1992.

TO THE FUTURE

The Southwest Pacific has enormous gold potential. Over the past five years, annual gold production has increased by about 50%, from 890,000 oz (27.7 tonnes) to 1,330,000 oz (41.4 tonnes), and by mid-1990 this figure is expected to more than double. By the mid-1990's the western Pacific rim - including Australia, the Philippines and Indonesia could well become the second-largest gold producer after South Africa (see Figure 4). The existing and postulated annual gold production of the south and western Pacific is shown in Figure 5 (and see Lum, 1990). Papua New Guinea alone is projected to produce some 2.7 million oz (about 84 tonnes) of gold per year, valued at nearly US\$1 billion at today's price, by the mid-90's. The Ladolam deposit on Lihir, off New Ireland, may yet become the largest gold deposit in Papua New Guinea, larger than Ok Tedi, with gold reserves of some 19 million oz of gold at a cut-off grade of 1.5g/t, and valued at nearly US\$9 billion at today's gold price. The enormous Grasburg deposit in eastern Irian Jaya, not far over the border from Ok Tedi, reinforces the message of this review.

The returns on investment have been such that the growth in the mineral sector has risen despite the political problems on Bougainville. With at least three medium to large gold mines on the point of production or coming into production within the next three years (Lihir, Hidden Valley, Mt Kare) and with the development of the country's first commercially viable oil field at Iagifu-Hedinia in the Southern Highlands, the immediate outlook for Papua New Guinea is most promising: its possibilities are proven but, it must be stressed, not by any means exhausted.

In Solomon Islands, government is

expected to announce its first significant mining lease for hard rock development at Gold Ridge, central Guadalcanal. Gold reserves are quoted at 1.3 million tonnes of about 3.9 g/t, valued by the company at about US\$40 million. Other prospects are likely to be released for further exploration in the near future.

In Vanuatu, exploration has slowed following the collapse of the boom markets in Australia in 1987. The prospects on Espiritu Santo, Malekula and Efate have yet to be evaluated.

In Fiji, the Emperor mine is expected to continue annual production of around 135,000 oz. As well, on Vanua Levu, a relatively small prospect at Mt Kasi is being evaluated. As a mine it would produce about 16,000 oz of gold per year for about five years. With the price of copper high, the Namosi copper prospect is being

actively assessed and could be developed as a significant copper/gold prospect of a size comparable to the Bougainville mine.

Table 1 shows the reserves and characteristics of the major deposits of the Outer Melanesian region. Some of these are in world class range.

Political stability has been tested over the last three years both in Fiji and Papua New Guinea, but the mineral industry has continued and improved because governments generally maintain support for and encourage foreign investment. For example, the Misima and Porgera mines were developed despite the problems on Bougainville. Because of the epithermal character of the gold deposits, and the resultant relative ease of mining by open-pit methods, and because gold prices are expected to hold, the long-term outlook for the region Papua New

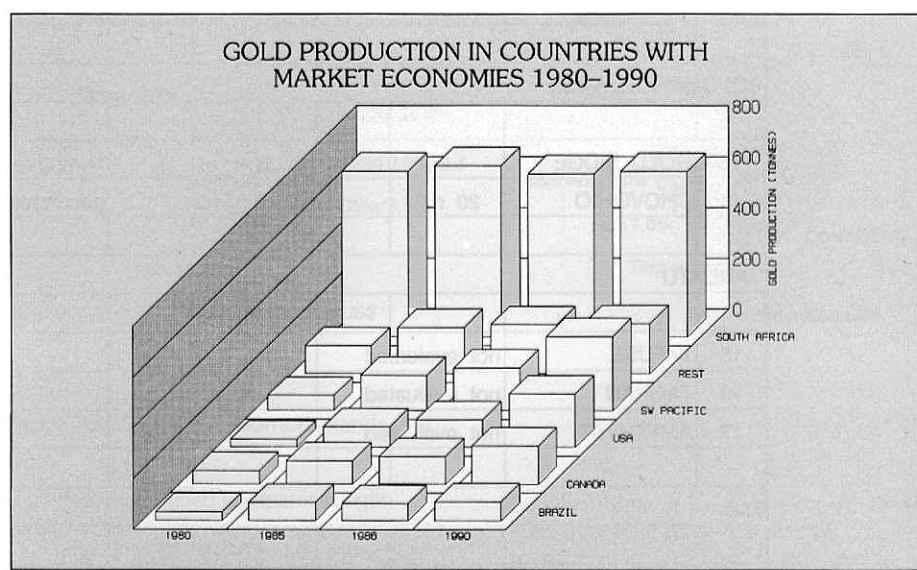


Figure 4. Gold Production Southwest Pacific compared with other producers.

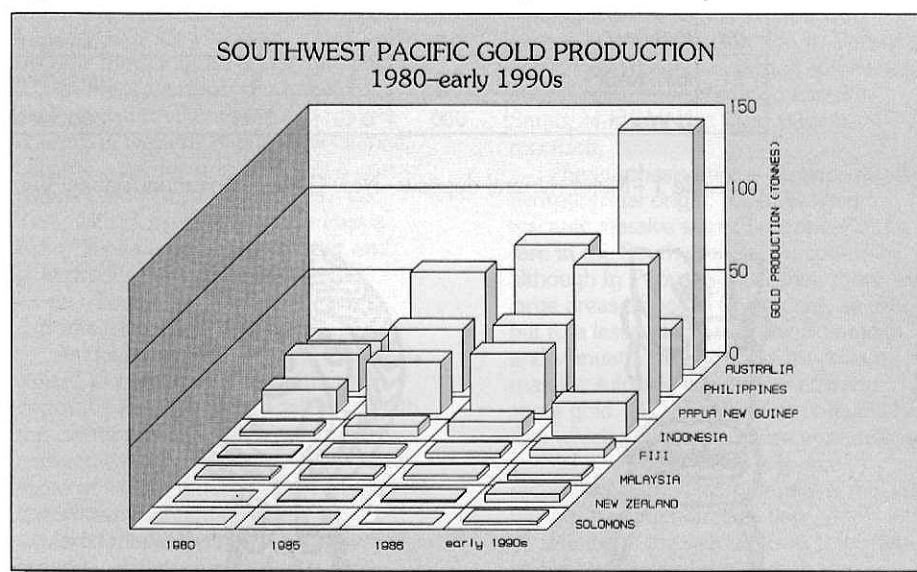


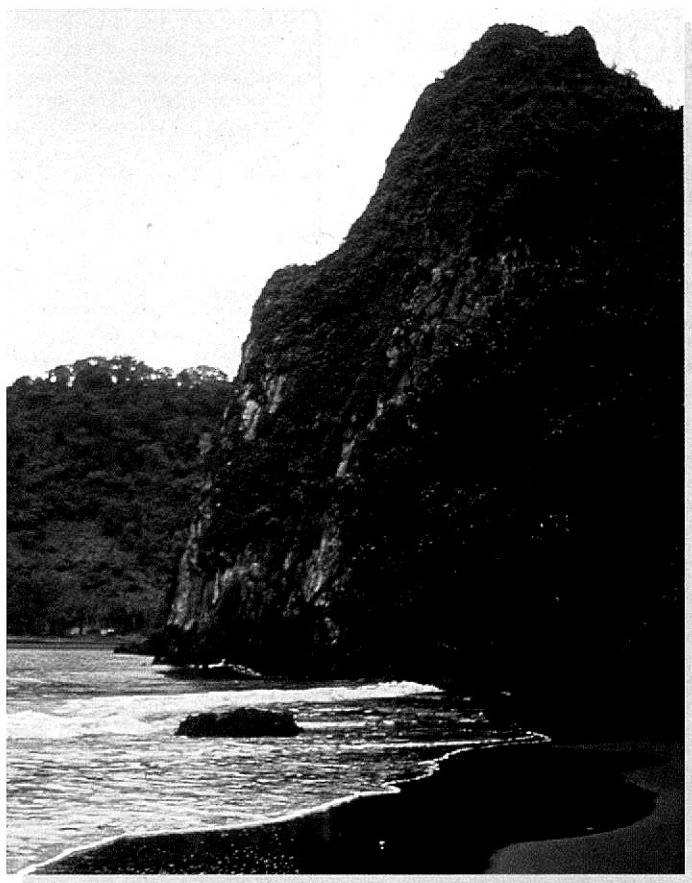
Figure 5. Gold Producers in the South Pacific.

Guinea-to-Fiji is attractive. Further vigorous exploration using recently developed ideas on island arc structures, especially the role of strike-slip faulting (see "Fault Systems ..." below) in the emplacement of epithermal deposits, and refinements in high-technology airborne geophysical exploration methods (e.g. in low level geomagnetic, gravity and radiometric surveys) will surely result in more discoveries.

A brief history of gold exploration in the individual countries of the region, a description of recent discoveries, and the prospects for their futures are given later on in the section —Gold Profiles.

ANCILLARY OPPORTUNITIES.

The present and projected growth in both mining and exploration activities in the region has within it a range of opportunities (see Lum & Callicutt, 1989). In the exploration field, opportunities exist for grass roots exploration, joint-ventures, consulting services not only in direct geological exploration but also in engineering and in the important environmental assessments that are now a routine part of development, and in transport, construction and metallurgy, during feasibility studies. During development and production, commercial openings exist for equipment sales, mine supplies, mine and plant construction, infrastructure construction, office



Lihir Island.



Hi-graders Mt Kare.

supplies and in investment.

Expenditures on already-announced gold projects and exploration in the region over the next five years are estimated as follows: for capital expenditure associated with construction for at least six gold projects — US\$2.25 billion; for exploration, annual expenditure of at least US\$100 million. All of the planned projects for the region (Figure 2 and Table 1) have an expected minimum operating life of 5 - 10 years with an average of 12 to 15 years. A significant portion of this estimated expenditure is attributed to "mine consumables" such as chemicals, carbon, grinding balls, liners and the like (Lum & Callicutt, 1989)

Regional Geology and Tectonic Setting –

Implications for gold exploration

The island chains that stretch from New Guinea through the Solomons and Vanuatu to Fiji (Figure 6) occupy a large part of the boundary between the Indo-Australian and Pacific tectonic plates is (part of the so-called Pacific “Rim of Fire”). As parts of Tertiary island arc systems, volcanic activity along these chains goes back at least to early Oligocene/late Eocene time, some 35-40+ Myr ago. The full range of island arc igneous rocks is present, including ultramafics, serpentinites, gabbros, basalts, basaltic andesites, dacites, and calcalkaline tonalites, diorites and granodiorites, and rhyolites. Also, as arc systems these island chains had an inbuilt propensity for the generation of high level intrusions and their accompanying hydrothermal systems. The reasoning behind this proposition is contained in this section.

Befitting an orogenic belt, the tectonics, structure, and geology of the countries of the Outer Melanesian system are extremely complex. What follows is an approximate synopsis.

ESSENTIAL GEOLOGY

The geologies of the components of the Outer Melanesian arc system - central/northern Papua New Guinea, Solomon Islands, Vanuatu and Fiji - have essential similarity. As parts of an intra-oceanic arc system they appear to have grown in keeping more or less with such arc models as that of Coleman (1978) (see Figure 7). They developed from a new subduction system as a thickened rim on the superposed plate. The downgoing slab governed the style and nature of the intrusives and extrusives that went to build up the foundation pile of the arc: the igneous rocks of this basal pile were made up of portions of original oceanic crust, boninites and arc tholeiites. With the passing of time and the increasing depth of the slab, the arc pile became thicker and more extensive, an accretionary complex was developed so that even at this juvenile stage the mix of rock types was extensive. Rocks of the

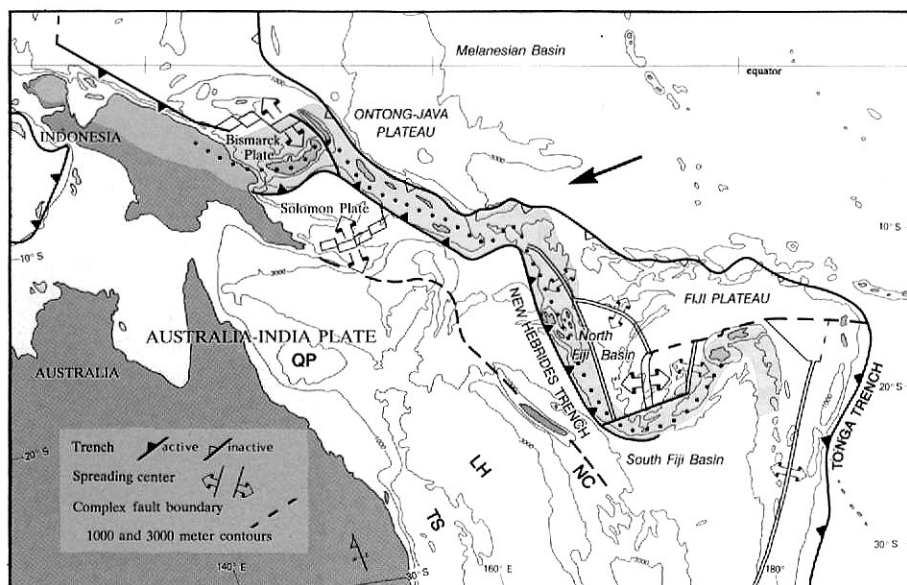


Figure 6. Major Tectonic Features, Southwest Pacific: Outer Melanesian arcs in yellow, with dots. Inner Melanesian arcs - dashed line.

accretionary complex - deep-sea pelagite sediments, detached fragments of oceanic crust including ophiolite wedges, amphibolites and oceanic basalts - were thrust against tholeiitic basalts, gabbros, dacites, ultramafics, and pelagite sediments in small quantities. With thickened crust and still deeper penetration of the slab, the arc body shoaled and breached the sea surface. The intrusives and extrusives became increasingly calcalkaline in nature and great volumes of extrusives and tephra were ejected. Tuffs and epiclastic sediments gave rise to turbiditic and other wackes including polymictic conglomerates and olistostromes. This growing sedimentary sequence includes carbonates, especially reefal bodies. By now the arc system, in terms of rock genesis, is approaching maturity.

Along such a long boundary, and over such a long time (perhaps 30-odd million years) this action was not uniform. Parts of the system were more active than others at any given time. Some grew faster. Most underwent stillstands. Some were affected by drastic changes in tectonic style. As will be seen, the Fiji group has been greatly affected by rotation of the Fiji platform; Vanuatu has undergone arc migration along with subduction reversal; such subduction reversals have brought about collisions of western parts of the system with the Australian craton to create northern New Guinea. These dramatic tectonic changes have greatly modified and fashioned the growth of arc crust. The crust features an extremely varied mix of rock types, often in apparently anomalous juxtaposition. As well, vigorous tectonism brings about profound geomorphological changes, especially in vertical relief. High energy

differentials promote vigorous erosion and the production and distribution of epiclastic sediments.

TECTONICS, STRUCTURE

The present-day regional plate tectonic setting of the Southwest Pacific is shown in Figure 6. The Cenozoic history of the Southwest Pacific, of which New Guinea, the Solomon Islands, New Hebrides Archipelago and Fiji are prominent parts, describes a time of vigorous dismemberment of eastern Gondwana, a process that began in mid-Cretaceous.

The latest Cretaceous/ Paleocene was marked by the build-up of arcs, probably of Andean-type, along the eastern margin of the Australian craton. By the end of the Paleocene, the westerly-directed subduction zone (or zones) had retreated (rolled back), a great marginal sea (in part the present Tasman Sea) had been created by asymmetric spreading about a disjointed NNW-SSE spreading ridge, and what had been the eastern margin was now submerged. An easterly jump of this spreading ridge created a minor back arc basin.

By the Eocene, an Inner Melanesian arc system stretched from New Guinea, through Pocklington Ridge — Rennell-Bellona — New Caledonia — Norfolk Island — Three Kings Rise to New Zealand. Today, all this is preserved as the Tasman Sea, the submarine Lord Howe Rise, the New Caledonian Basin (the minor back arc basin), the New Caledonian-Norfolk Ridge (initialled in Figure 6).

Also at about this time (?Late Eocene) an Outer Melanesian arc system began its development oceanwards of the Inner Melanesian system, along what

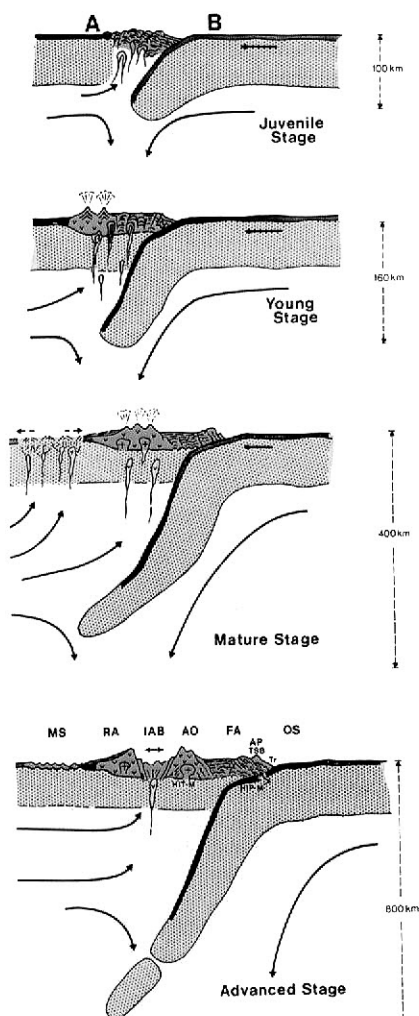


Figure 7. Model of island arc development: A&B-opposing plates; MS-marginal sea (backarc basin); RA-remnant arc; IAB-interarc basin; FA-forearc; OS-outer trench swell; AP-accretionary prism; TSB-trench slope break; HiT-M-high temperature metamorphism.

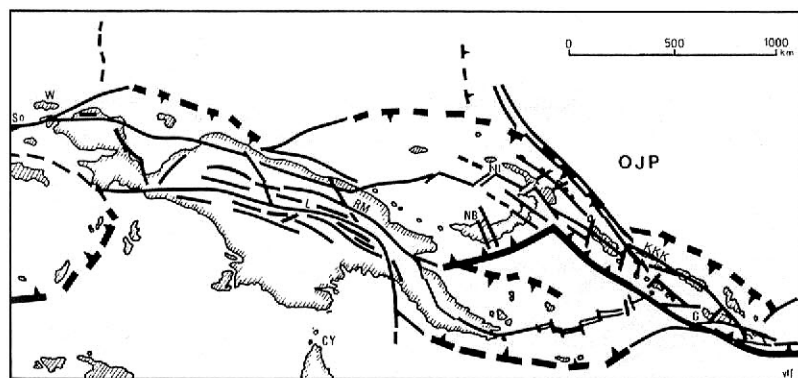


Figure 8. Some major tectonic features, with major faults emphasised, of the Melanesian Boundary, New Guinea to Solomon Islands. Only the most prominent faults are shown. Past subduction zones are indicated by arrowed, broken, heavy lines. Spreading centers shown by double lines. Most of the present, and past, subduction zones transform to major strike-slip fault systems. W-Wageo; So-Sorong Fault; L-Lagaip Fault; CY-Cape York, Queensland; RM-Ramu-Markham Fault; NB-New Britain; K-Kia/Kapita/Korigole Fault; G-Guadalcanal.

is now the border between the Indo-Australian and Pacific plates (the Melanesian Boundary). The outer arcs included parts of what is now northern New Guinea, Bismarck Archipelago, Solomon Islands, New Hebrides Archipelago, Fiji-Lau and Tonga. Shoaling was rare so that terrigenous sedimentation was minor until the latest Oligocene.

The Oligocene was marked by the development of an extremely large marginal sea, between Inner and Outer arc systems. Along the length of the Outer Melanesian arcs, the latest Oligocene/Miocene marked the onset of extensive growth of reefal carbonates, vigorous terrigenous sedimentation, the emplacement and extrusion of calcalkaline magmas and the collision of western parts of the system with the northern edge of the old Australian continent (roughly along what is now the spine of new Guinea). By the end of the Miocene, arc reversal along the Solomons-New Hebrides line had begun, with the onset of clockwise rotation of the New Hebrides and the anticlockwise rotation of Fiji and this led to partial closure of the great marginal sea (the South Fiji Basin is a remnant). The Melanesian boundary was now in much the same form and position as it is today.

The Solomon Islands now face southwest (Figure 6) and have a new volcanic front, marked by the New Georgia Group and volcanoes to the west and east of the Group. The New Hebrides arc faces west with a southern tail of new volcanoes and is in imminent collision with the New Caledonia/Loyalty block. The New Hebrides connects with Fiji by way of the Hunter transform fault. The growth of the North Fiji submarine plateau accompanied the rotation and disruption of the Fiji platform. The rotation was also marked

by the injection of shoshonitic magmas, especially on Viti Levu.

As well, this Melanesian Boundary is marked today by a wide zone of long faults, deeply penetrative, parallel and subparallel to the boundary trend, together with collision zones and minor spreading ridges. Most of the boundary is shown in Figure 8. In the central part, the convergence is about 72 degrees (Figure 6), the relative obliquity decreasing to the west (the rotational pole is a few hundred kilometers east of southern New Zealand). The convergence is about 110 km/myr.

From New Britain westwards, faulting is especially strong and intense (e.g. Abers & McCaffrey, 1988; Cooper & Taylor, 1987; and see regional geological map of Papua New Guinea), and includes such major faults as the Ramu-Markham, Sorong and Lagaip-Sula systems (Figure 8). But this is also a region of past, present and pending collisions on a scale so large that the behavior of individual fault blocks is extremely difficult to fathom. Much of the northern flank of New Guinea consists of allochthonous terranes that have been transported to their present position by strike-slip action. The picture for the Solomons/New Hebrides general region is a little simpler, but becomes more complex in the area of the Fiji platform, with rotational movements, and the shifting of terranes.

The geometry of the present interaction between the two main plates, and a couple of smaller ones, is discussed by Wells (1989). A Cenozoic history of Pacific/Australia-India plate interaction is detailed by Kroenke (1984) and a summary version is given by Smith (1990).

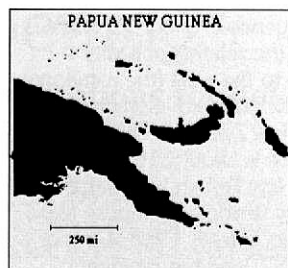
IMPLICATIONS

This simplified account has high relevance to the search for gold, for it emphasizes that the crustal build-up of most of Papua New Guinea and the island chains east to Fiji has followed a complex pattern marked by subduction reversal, by creation of marginal seas, and by crustal collisions. Complex crust with complex history augurs well for the emplacement of hydrothermal deposits with high metal content. All areas have shared in calcalkaline magmatism.

Along with crustal complexity, strike-slip fault movements along the Melanesian Boundary have an important bearing on the strategy, and especially the tactics, of exploration for precious metals. This is discussed in the section Fault Systems ... below, p.25.

Gold Profiles -

Gold Search, Production, the Future



PAPUA NEW GUINEA

History. Before the coming of the European mariners and traders to the Pacific, gold was not used or valued by the peoples of Papua New Guinea. The first references to gold discovery were made by Alvaro de Saavedra, a Spanish captain who, in 1528, found traces of gold on the north coast of what he named Isla de Oro, the island of gold - a fanciful name for present-day New Guinea (Sharp 1960). His report attracted many adventurers to the Pacific. One of them, Mendana, sailed

from Mexico to discover this golden island and found the Solomons. In subsequent years, occasional gold colors were reported but were not sufficient to arouse any real interest or justify Alvaro de Saavedra's report.

In 1873, Captain Moresby of HMS Basilisk reported minor gold deposits in the Laloki hills behind Port Moresby harbor. By 1877, there was a rush of approximately 100 European miners to the area. Little gold was found and many of the miners died of malaria. It was not until 1888 that the first significant gold discovery was reported on Sudest Island by David Whyte, captain of a trading ship (Nelson, 1976). This started a series of gold rushes around eastern Papua. The alluvial and lode deposits at Lakekamu, Misima and Woodlark were discovered during this period. The first lode mine in Papua New Guinea was opened on Woodlark in 1907. By 1926, total gold production was some 500,000 oz (15.5 tonne), of gold (Nye and Fisher 1954).

In 1922, further northwest of the gold rush area, "Shark-eye" Park relocated an early discovery and started mining in the Wau area. Rich alluvial gold was discovered in Upper Edie Creek, where up to 240 oz per day were recovered in a single sluice box (Lowenstein, 1982), and this led to a

rush in the area. Soon after, dredging operations were established.

The Bulolo Gold Dredging Company, partly owned by Placer Development Ltd, in a pioneer use of aircraft, airlifted eight dredges to operate in the area. Gold production to 1940, when operations ceased because of the Second World War, was 2,800,000 oz (Loudon, 1987). After the war, efforts were made to re-establish the dredging operations, but by 1966 all dredging had stopped. Since then, small-scale sluicing and hand-panning has continued. Up to 1989, Renisons Goldfields Consolidated Ltd. operated small open-pit mining and sluicing operations at Wau. The majority of miners in the area are nationals, who mine alluvial gold with crude sluice boxes and by hand panning. The Morobe Goldfields have produced about 3,500,000 oz (109 tonne) from 600 million cubic yards of alluvium and about 500,000 oz from fracture vein and filling deposits (Loudon 1987, with other gold references). Gold exploration by lone explorers and nationals expanded to the inland of Papua New Guinea. Small alluvial workings have since been discovered in the Highlands, Maprik and at Kainantu.

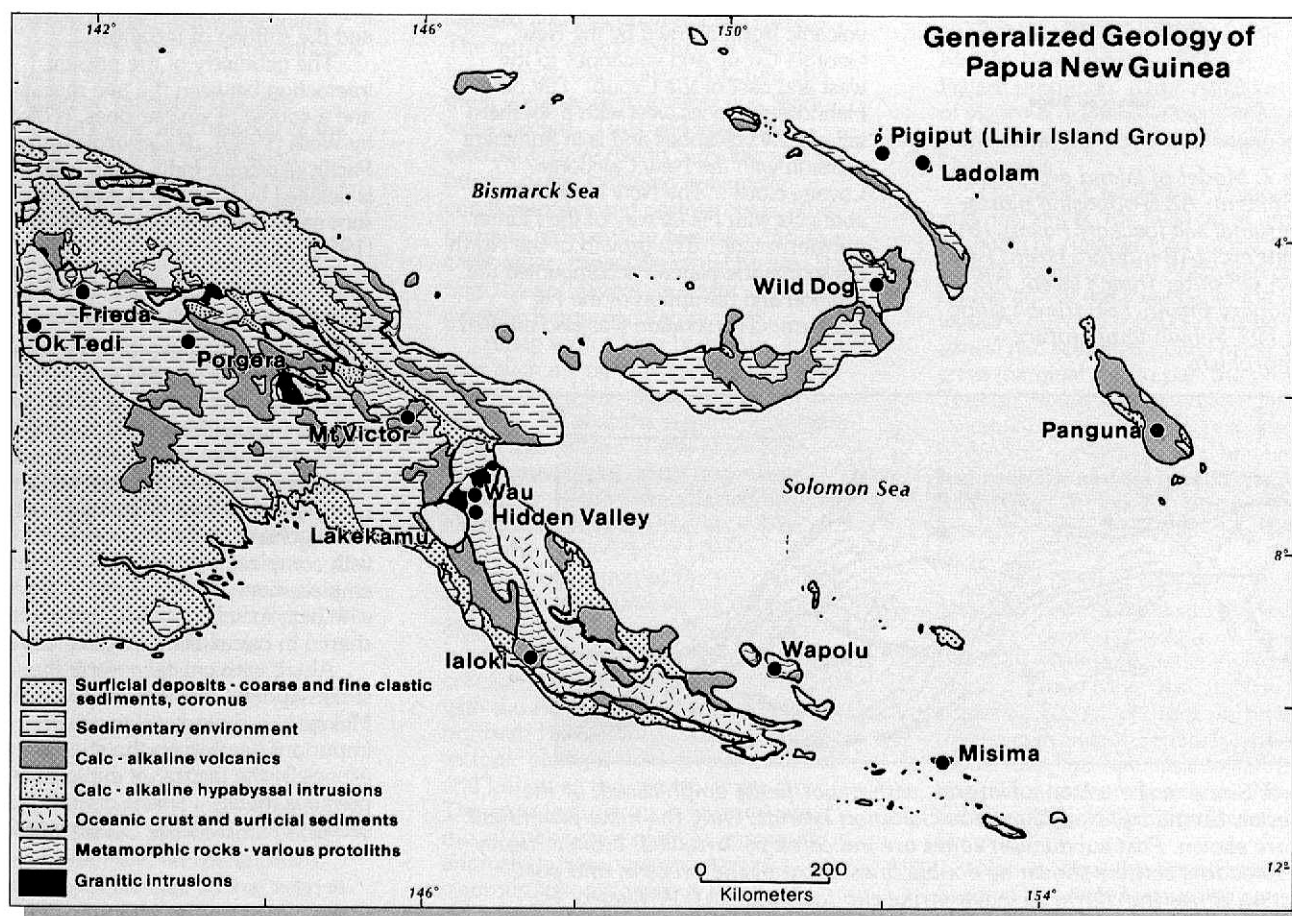


Figure 9. Generalized Geology of Papua New Guinea with locations of major mineral deposits.

Recent Developments

Papua New Guinea is a minerals-led economy; mining accounted for almost 20 percent of GDP and 60 percent of total export receipts in 1989. Gold and copper have been the leading export earners since 1972, when the Bougainville mine commenced full production.

The giant porphyry copper deposit at Panguna on Bougainville Island was discovered in 1961 by Conzinc Rio Tinto of Australia (the presence of copper at Panguna had been known for some years). Production from the mine began in 1972. Total production through December 1988 was three million tonnes of copper, 298 tonnes of gold, and 765 tonnes of silver (Papua New Guinea Minerals, Energy and Mines 1988). The development of the copper-gold mine portrayed Papua New Guinea as a country with enormous mineral potential and led to a flow of international mining companies into the country.

Discoveries of the Frieda River porphyry copper deposits and the Ok Tedi gold deposit, western Papua New Guinea, followed in 1966 (Figure 9). The Frieda deposits have been evaluated as subeconomic because of the apparent low content of gold (so had Porgera!). The Ok Tedi deposit was marked by an especially valuable gold-rich cap and came into production in 1984.

For the 1980s, gold was once again the focus of exploration. Two major world-class gold deposits (Porgera and Lihir) and several large-scale deposits (Misima, Hidden Valley, Mt. Kare,

Tabar) gold deposits have been discovered. Porgera and Misima are now in production, whilst Lihir, Hidden Valley and Mt. Kare are either awaiting government approval for mine development or are in the final stages of feasibility studies.

The Porgera deposit located in the Enga Province of the Western Highlands, was discovered in 1938 but was not considered economically viable until 1989, when high-grade gold zones were intersected in drill holes. Current estimated geological reserves stand at 60 million tonnes at 6.5 g/t gold. At present, both underground and surface mine development is under way. Gold production from Porgera is expected to average about 20 tonnes/yr over the first ten years. Mining will commence initially with an underground operation treating about 1500 tonnes/day moving to open pit mining that will treat 6500 tonnes/day when the mine is in full operation. Construction of the first phase of 1500 tonnes/day is nearly completed at a cost of over US\$0.5 billion.

The Misima deposit on Misima Island in the eastern Papuan Archipelago, was discovered during the 1900s but it was not until recently that the project became major. Movable ore reserves at Misima total 60 million tons of 1.38 g/t gold with a cutoff grade of 0.7 g/t and 21.0 g/t silver. Construction started in January, 1988. Commissioning of the plant began in April 1989 and the first bars of dore bullion were poured on May 1989. Full scale operations commenced in July 1989. Misima is an open pit mine

operation treating 15,000 tonnes of ore per day, and has an expected mine life of more than 10 years. Total amounts of gold and silver expected from the mine are estimated to be 2.48 million oz (77 t) gold and 38 million oz (1182 t) silver, worth nearly US\$1 billion at a price of US\$385/oz gold and US\$6/oz silver. The mine is expected to produce an average of 200,000 oz/yr over the 10-year mine life. At the end of 1990 (Jan-Dec), the mine produced 317,167 oz of gold (6.2 tons) and 2,566,651 oz of silver (82.5 tonnes) (Placer Pacific, 1990). Capital cost of development including capitalized pre-production operating costs but excluding financing cost was US\$180 million.

The Ladolam deposit on Lihir Island (Figures 9 & 10), reportedly the largest single gold deposit outside South Africa, was discovered in 1983. The current estimated minable ore reserve is given as 163.6 million tonnes averaging 3.7 g/t with a 2.0 g/t cut-off value. Contained gold is some 19 million oz (600 t) at a waste to ore ratio of 3.6:1 (Mining Journal, 4 May 1990) in two main zones. A major feasibility study for the development of a mining treatment operation is under way and scheduled for construction in the early 1990's. The mine is estimated to cost US\$900 million, and will treat ore at 10,000 t/day producing an average 800,000 oz (25t) per year over the first 10 years. A total mine life of 37 years is anticipated.

The Mount Kare deposit in the Southern Highlands is located some 20km from the Porgera gold mine. Discovered in early 1988, it has yielded gold nuggets as big as a fist. Unofficial figures show that in the first eight months an estimate of four tonnes of gold have been produced by national miners employing basic panning methods. The size and grade of the deposit are still unknown. Currently a joint venture between CRA and landowners has been formed to start mine development. Gold production is expected to begin in 1991.

Elsewhere in Papua New Guinea, numerous prospects are in the advanced stages of exploration and detailed evaluation work is continuing. At Hidden Valley, near Wau, feasibility studies have defined 37 million tonnes of ore at 1.68 g/t gold and 26 g/t silver. The ore is minable by open pitting and able to be processed by direct cyanidation in a CIP circuit. At Wapulu on Ferguson Island (Figure 10), some five million tonnes of 1.43 g/t silver have been reported. In the Tabar Islands, not far from Lihir, ore reserve evaluation is being conducted by an extensive drilling program, the results of which to date are encouraging. Other

Estimated Annual Gold Production of New Projects for the Early 1990s	
Projects	Annual Production
	OZ
<i>Lihir</i>	<i>800000</i>
<i>Mt Kare</i>	<i>na</i>
<i>Hidden Valley</i>	<i>185000</i>
<i>Lakekamu</i>	<i>70000</i>
<i>Wapulu</i>	<i>40000</i>
<i>Simberi</i>	<i>30000</i>
<i>Laloki</i>	<i>na</i>
<i>Woodlark</i>	<i>na</i>
<i>Wild Dog</i>	<i>20000</i>
<i>Total</i>	<i>1145000+</i>
<i>Source: Lum and Callicutt, 1989</i>	

Table 2. Estimated Gold Production from new mines, Papua New Guinea

advanced prospects include Laloki in the Central Province, Woodlark on Woodlark Island, and Uramit (Wild Dog) in East New Britain. Table 1, above, lists the reserves and the characteristics of major deposits.

Mining in Papua New Guinea had a setback on Bougainville during November 1988, when acts of sabotage started at the Panguna mine; in May 1989, the mine stopped all operations. The sabotage is connected with issues concerning landownership, dissatisfied landowners, and secessionist sentiments. The mine remains closed although negotiations to re-open are continuing. In January 1991, an accord was signed between the Papua New Guinea National Government and the Bougainville delegation at a peace-making meeting in Honiara, Solomon Islands. The accord agreed that long term political status of Bougainville is to be addressed as part of a continuing dialogue. The accord also agreed to the return of services, particularly health, education and communication as an urgent priority. The re-opening of the Panguna mine is an important item on the new agenda. Economically, the closure of the Bougainville mine has had a significant impact on Papua New Guinea's export earning and government revenue, for it has deprived Papua New Guinea of about 20 percent of its exports. With good government foresight this impact was cushioned temporary by the existence of gold and copper reserves and the Mineral Resources Stabilisation Fund. Since 1972, the mine has provided 45% of gross exports and contributed 17% of the central government's total internal revenue.

There have been three significant gold production surges in Papua New Guinea: (i) during the 1888-1926 gold rush period along the southeast tip of the country (Sudest Island, Lakekamu, Misima and Woodlark); (ii) at the time of the exploitation of the Morobe goldfields in 1930-70s; and (iii) during the 1970s to the present when the giant porphyry copper-gold deposits were developed and mined. A fourth, lesser surge is expected in the mid-1990s, and will come from the development of epithermal gold deposits, including Lihir, Hidden Valley and Mt Kare (Table 2).

Gold Production

There are at present three operating gold mines in the country: Ok Tedi in the Star Mountains in the West Sepik Province, Misima mine in the Milne Bay Province, which was officially opened in June, 1989, and the Porgera mine in the Enga Province which started production in September of

1990. As mentioned, the Bougainville mine was closed in 1989. The contributions of various mines towards total annual gold production for the period 1983 to 1989 are illustrated in Figure 10. Total gold production of Papua New Guinea in 1989 was some 1,025,370 oz (32t) compared to 1,189,000 oz (37t) in 1988. This significant decrease is attributed to the closure of the Bougainville Mine and to a mechanical failure at the Ok Tedi mine that resulted in the mine working at below target capacity. The decrease would have been more pronounced if the newly opened Misima mine had not contributed 150,000 oz of gold (4.7 t) during the year. Since the development of the OK Tedi mine in 1984 the country's production figures have almost doubled. Ok Tedi mine annual gold production figures have been

marginally greater than Bougainville. In the immediate future, however, Ok Tedi gold production is expected to decrease slightly with the depletion of its rich gold cap but it will still maintain a production of 500,000 oz (15.5 t) of gold per year.

Despite the delay in the re-opening of Bougainville, gold production in 1990 is expected to return to 1988 levels because of the full development of the Misima mine and the start of production at the Porgera mine and also possible production from Mt. Kare. Gold production for 1991 will increase substantially with Porgera coming into full production. The Porgera mine is expected to produce 800,000 oz (25 t) of gold per year. Should the Bougainville mine be reopened in 1991, annual total gold production for the country could be about two million

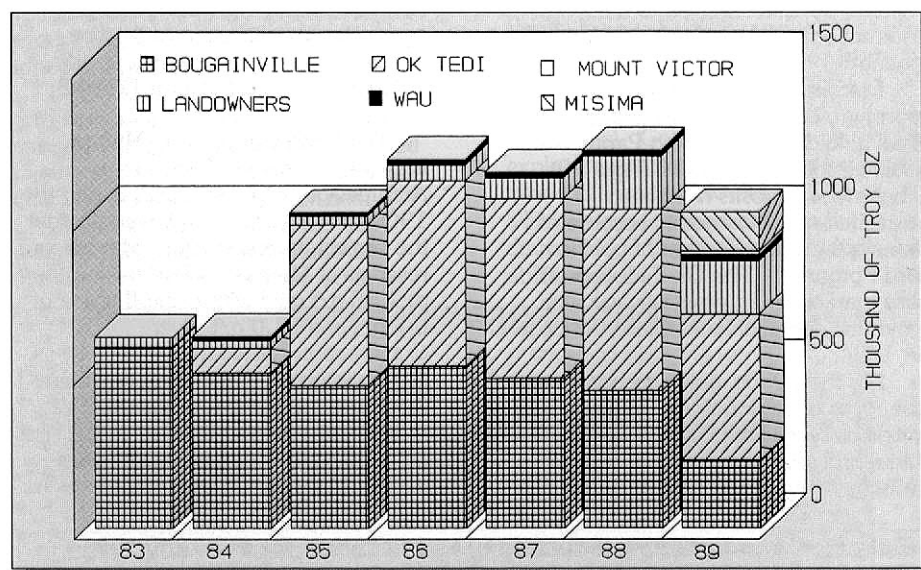


Figure 10. Gold Production from major mines, 1983-1989, Papua New Guinea.

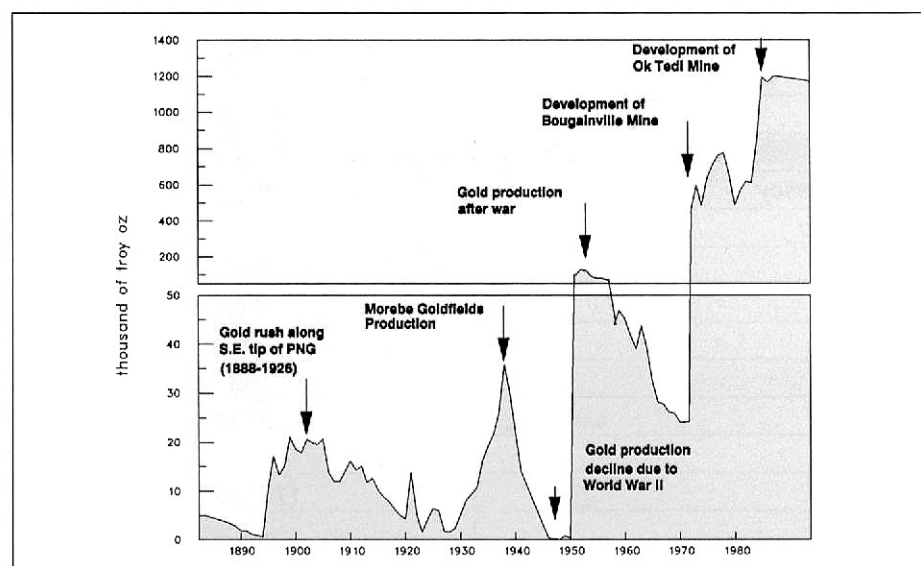


Figure 11. Track of Gold Production 1890-1988, Papua New Guinea

oz. Total gold production since 1888 when the first gold rush took place in the hills of Laloki behind Port Moresby Harbor, is some 15.4 million oz (479t) (see Figure 11).

Future Outlook

Since 1986, Papua New Guinea has been ranked ninth among the world's leading gold producers. With the added production of Misima mine and Porgera mine and the development of Lihir in the next few years, gold production will increase substantially and raise the ranking to at least sixth. This assumes that there are no adverse political developments and that production trends in major producing areas continue.

The immediate and long term outlook for gold exploration and development is promising. With normal political stability maintained, the country should enjoy substantial investments from gold exploration and mining. Gold will continue to play a leading role in economic development and will continue to be the largest export earner for the country. An earlier figure, Figure 5, compares Papua New Guinea with the rest of the leading gold producers through the eighties. Gold production figures for new projects are given in Table 2. An additional one million troy ounces per year is likely to be produced in the mid-1990s should all the listed projects be developed. Total annual production would be some 2.7 million troy ounces (84 tonnes) by mid-1990s.

Investment Opportunities in the Papua New Guinea Gold Industry

Of the Southwest Pacific countries, Papua New Guinea is the most attractive for gold mining and exploration - which is not to say that excellent opportunities do not exist in the other countries (Lum, 1990; Lum & Callicutt, 1989). But Papua New Guinea is the largest and is geologically the most favorable for gold occurrences. Most of the region's current world class gold deposits and large-scale projected gold developments are in Papua New Guinea. Three major projects - Lihir, Hidden Valley and Mt. Kare - are expected to come into production by the mid-1990's. Figure 12 compares Papua New Guinea, Solomon Islands and Fiji annual gold production for the period 1981-1989. Papua New Guinea production figures tower above those of Fiji and Solomon Islands. Opportunities exist in Papua New Guinea in the following areas:

- **Financing.** Lending institutions will need to have about US\$2 billion available to the mining companies to finance the capital expenditures for gold mining and milling facilities over the next five years.

- **Equipment and technology sales.** These include carbon-in-pulp, which will be used at Misima, and pressure oxidation for the refractory ores at Hidden Valley and Lihir.

- **Chemicals and supplies.** Sodium cyanide use in Papua New Guinea is projected to be 30,000 tonnes in 1991 and is expected to increase throughout the decade. The market value of cyanide production, 1990, is about US\$35 million.

- **Modular equipment.** Many of the smaller deposits in Papua New Guinea will be in remote areas. The



The Ok Tedi mine

building of permanent or semi-permanent infrastructure will be impractical. The use of modular infrastructure and modular processing plants will be a likely solution.

- **Joint ventures.** Much of the grass-roots preliminary exploration has been done by junior Australian exploration firms. These firms were hurt seriously by the 1987 stock crash. Many are desperately seeking partners to continue exploration on promising prospects.

- **Warehousing/distribution.** Each large project takes care of supply procurement, warehousing, and distribution. A central warehousing/distribution network is feasible.

- **Grass-roots exploration.** Although there are currently some 250 licenses in force, it must be stressed that much of the country has been little explored for gold because of the rough terrain, access problems and logistics. Many geologically favorable areas are still open to exploration.

- **Local business.** There will be opportunities for a range of local business e.g. supermarkets, local farm produce distribution, local technical contracts and so on.

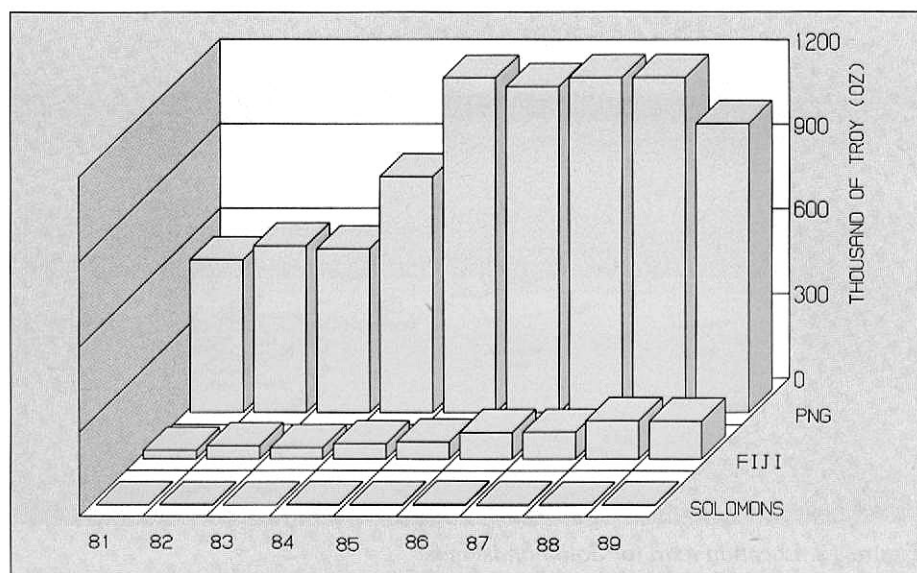
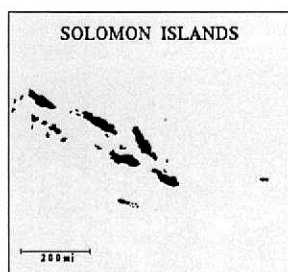


Figure 12. Gold Production - Papua New Guinea, Fiji, Solomon Islands.



SOLOMON ISLANDS

History

A location map of Solomon Islands is shown in Figure 13. The archipelago of the Solomon Islands was named after King Solomon (and his legendary gold mines!) by Spanish explorer Alvaro de Mendana in 1568 when he came upon them while searching for the "island of gold" rumored to have been discovered by another earlier mariner, Alvaro de Saavedra, in 1528 (Grover, 1955). Mendana discovered gold at the mouth of the Metapona River on Guadalcanal but was unable to explore extensively due to the hostility of the Solomon Islanders. Mendana also reported gold on the islands of New Georgia, Santa Isabel, and San Cristobal. In the 1880's, a trader named Sorenson led a group which eventually located and mined alluvial gold at Maru Bay on San Cristobal. In 1919, some gold was reported mined from a lode near Wanderer Bay (southwest Guadalcanal) by Young and Carpenter. The Solomon Islands experienced its first gold rush in 1929 in the Massey River in New Georgia, based solely on sightings of abundant pyrite and rumors of rich gold, but no gold was found.

In 1931, prospecting and mining activity continued intermittently in the valleys of the Balasuna, Sutakama, and Sutakaki rivers and in the Metapona, Chovohio, and Tsarivonga River systems of western Guadalcanal. In late 1933, alluvial gold was discovered in the Tenaru River in Guadalcanal. The river was sluiced for gold by the Cliff brothers and the Olsens, but no production records are available. In 1936-37, gold was traced to the soils and bedrock on Gold Ridge and the deposit worked intermittently. During 1941, extensive sluicing at Gold Ridge was conducted by Balasuna Syndicate. During 1941-42, Emperor Mines Ltd. prospected the same area. During the same period, there were also numerous lease holders prospecting and mining alluvial gold around the Gold Ridge area and along the Chovohio River. With the invasion of the Japanese during the Second World War all operations

ceased. It was not until 1949 that exploration of Gold Ridge began again and the islands of Hanesavo, Buena Vista, Santa Isabel, and San Jorge were again searched for gold. The presence of gold on some of these islands was confirmed. During 1951-52 drilling was carried out in the Kovagombi area of the Chovohio River by Bulolo Gold Dredging Co. and the area was worked briefly.

In January 1960, a small manganese mining operation was started. One hundred seventy-eight tons of high grade ore from this mine, valued at 8,121 pounds sterling, was exported to Australia to supply battery manufacturers. Manganese mining ceased during July 1960 because of the financial burdens involved in acquiring machinery for removal of overburden.

Recent Developments/Gold Production

During the 1980 gold rush in the Pacific, the Solomon Islands, like its neighbors Papua New Guinea, Vanuatu and Fiji, experienced a flurry of companies applying for exploration licenses. In November 1985, the Solomon Islands government granted its first mining lease to an Australian and local joint-venture company to mine alluvial gold. Mining operations closed in 1987 due to internal company problems and damage caused by a tropical cyclone. The joint venture produced a total of 1,275 oz of gold. In May of 1990, an Australian company requested a mining lease to start mine development at Gold Ridge. Minable reserves of 1.34 million tonnes at 3.86 g/t Au have been defined by a feasibility study conducted by the company. A

decision for mine development will be announced by the government probably late in 1991. Gold production is expected to start in 1992 at a rate of 350,000 tonnes of ore per year producing some 32,000 oz of gold valued at some US\$12 million at US\$380 per oz Au.

Currently, gold production is limited to alluvial mining by landowners using hand panning and crude sluicing. In 1989, a total of some 2,000 oz of gold was produced. This production came from the Chovohio River which dissects the Gold Ridge Prospect. Figure 14 illustrates gold production reported for the period 1979-1989.

Future Outlook

Although the Gold Ridge mine will be a small mine by world standards, it will play a significant role in the economic development of the Solomon Islands. Currently, the mining sector contributes less than 1 per cent of the country's export earnings. With the development of Gold Ridge in 1992, export earnings for gold for the year are expected to be about US\$12 million accounting for about 15 per cent of total export receipts. The mine is expected to be short-lived, however, with a life of about five years.

The announcement of the new mine will generate further exploration interest in the country, boosting exploration expenditure and increasing the chances of new gold discoveries. The country is currently considering a new mines and mineral bill, which retains the basic concept of state ownership of minerals but will change the regulations governing the acquisition of surface access rights for prospecting and mining.

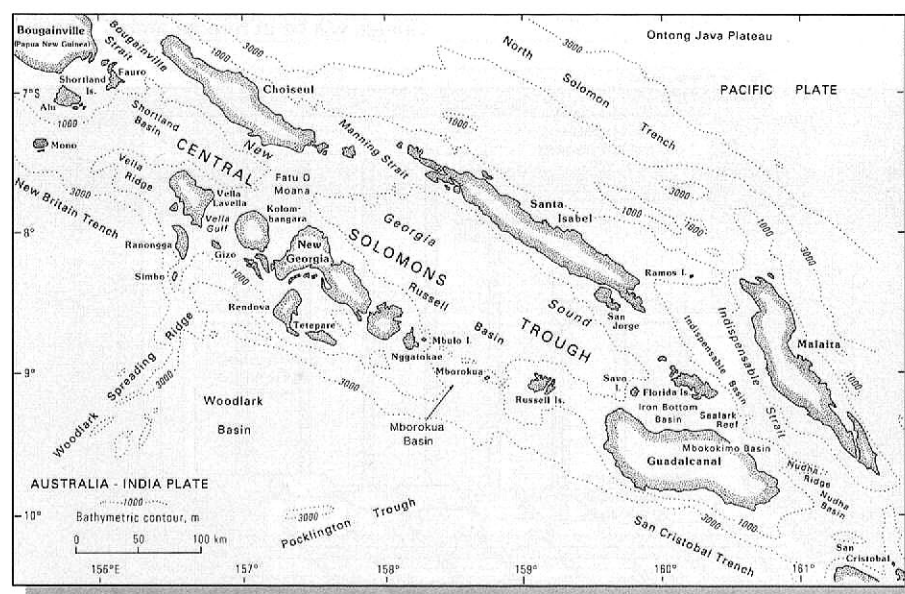


Figure 13. Location map for Solomon Islands

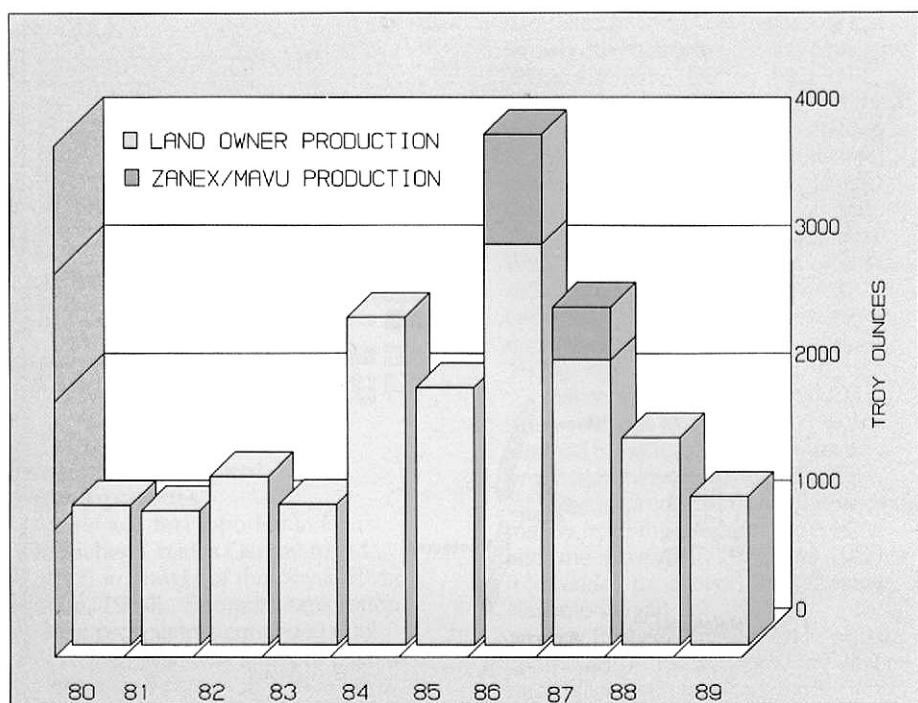


Figure 14. Solomon Islands Gold Production 1980-1989

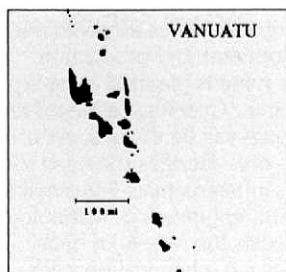
With Gold Ridge on the point of development, there will be various economic opportunities available during mine development and production. The Gold Ridge mine is planned to be an open pit mine. Cyanide treatment and carbon-in-pulp will be the process used for treating ore. Besides the need for equipment, infrastructure, and services (environment, engineering, technology etc) there exists the supply of mine consumables e.g. chemical supplies (cyanide, carbon etc). Other opportunities in the Solomon Islands include joint-ventures, grass roots exploration, financing, and warehousing and distribution.



Gold Ridge to Honiara, Guadalcanal



How much today?



VANUATU

History

Prior to the burst of activity in the Southwest Pacific, triggered by the Lihir discovery, near New Ireland, Papua New Guinea, Vanuatu's mineral exploration was limited to a pioneering effort by Douglas Mawson in 1903, by the French Phosphate Company in the mid-30s, porphyry copper exploration by CRA Exploration Company in 1968, the Noumea-based Bureau de Recherche, Geologie and Miniere (BRGM) in 1969-71, and Kennecott Exploration in 1972-73. Gold was first noted in Vanuatu, in the mid-30s near Mt Fatmalapa on Efate, by Aubert de la Rue, a geologist with the French Phosphate Company. There has been comparatively little detailed exploration for gold until recently.

Recent Developments

During 1985, after the discovery of Lihir, Vanuatu along with the rest of the island chains to New Zealand, was subject to an intense demand for tenement applications. Within a year, the Vanuatu government granted 130 licenses to various mining and exploration companies. Recent exploration by a few of these companies has resulted in the discovery of several epithermal gold and silver deposits (gold contents of up to 25g/t have been reported). The better known occurrences are the Taoran and Amethyst lodes on Malekula Island (Figure 15), the Tafuse North, Tafuse South and Webe Creek prospects on Espiritu Santo and an occurrence on Efate. Gold and silver mineralisation is associated with opaline siliceous veins, hydrothermal alteration, stockworking and/or eruption breccias. Mineral exploration is still very much at the grassroots stage: the very first diamond drill hole for gold was drilled in 1986 and today only three prospects (Taoran, Tafuse and Efate) have been drilled. Although its geology and tectonic history are intrinsically promising, Vanuatu is essentially a new prospect.

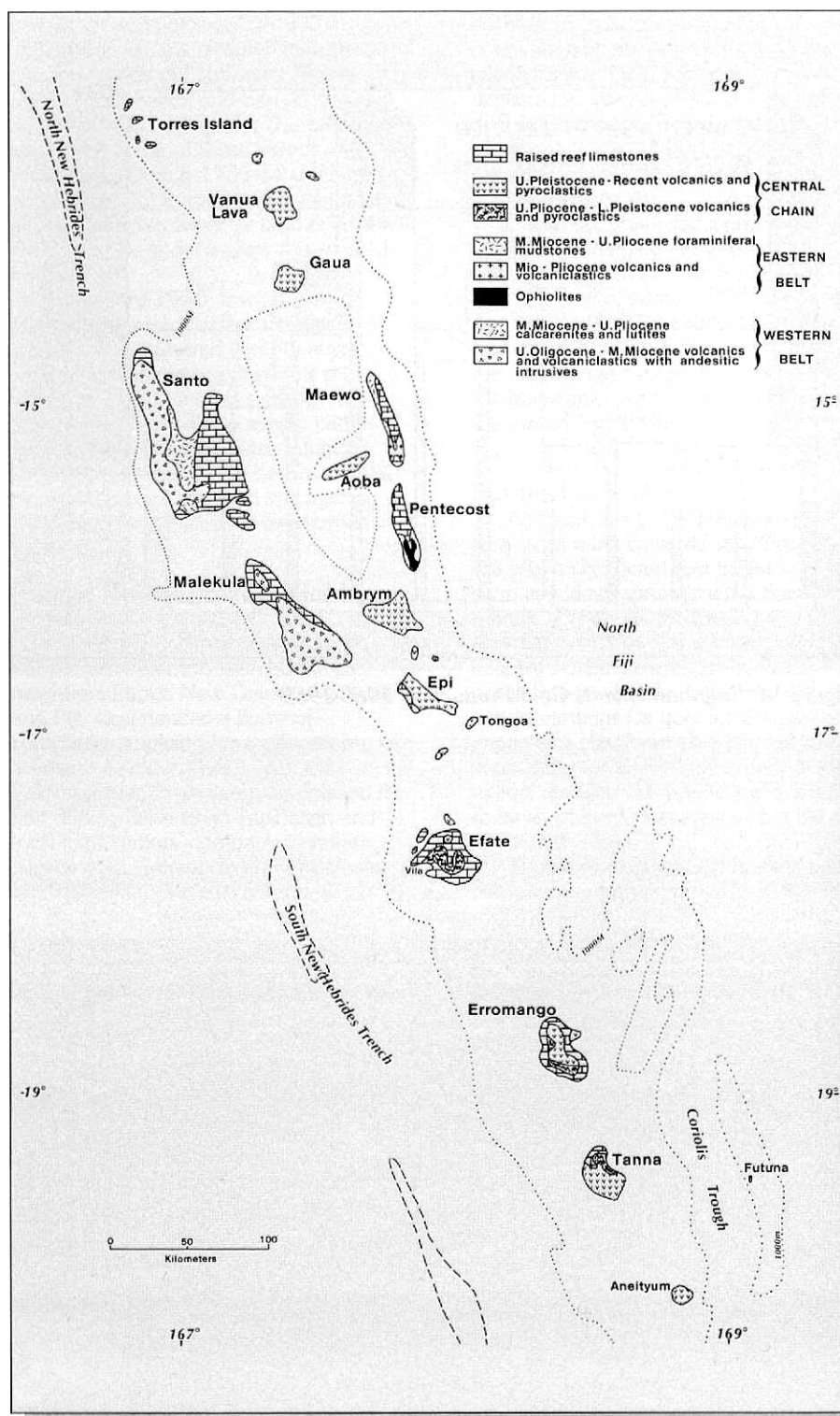
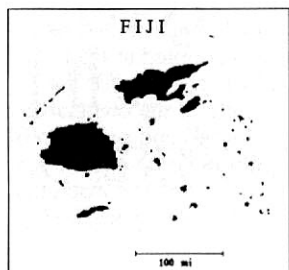


Figure 15. Generalized Geology of Vanuatu (after Carney & MacFarlane, 1978).

Future Outlook

Although there is at present no mining activity in Vanuatu, the country will continue to attract mining companies because of its favorable location, its arc geology, extensive Late Cenozoic igneous activity and complex geological history. Although intensive exploration has been lacking, recent results are favorable.



FIJI

History and Recent Developments

Gold was first reported in Fiji in 1868 when Charles Gurney found "colors" in gravels of the Navua River (Rodda, 1984). Sporadic exploration by lone prospectors continued until 1929 when gold was found in payable quantities at Yanawai in Vanua Levu. In 1932, gold was first mined at the Mount Kasi Mine at Yanawai. That same year, gold in economical amounts was discovered at Tavua in northern Viti Levu, the largest island (Figure 16). In 1935, gold production began at the Tavua Gold Fields (the Emperor Mine) and has continued to the present time. At Mount Kasi, gold production continued to 1946. After a drilling program involving 712.2 m of drilling

had failed to reveal extensions of the known ore shoot, the mining company closed the mine. During the 1940s, two small-scale gold mines on Viti Levu were developed (Mistry Mine and Vuda Mine), and several gold deposits were located where small amounts of gold were extracted (Waimanu River and Wainadoi, Waimotu and Dagunimba). With the Second World War, all small-scale mines and workings ceased because of the difficulty in obtaining explosives and machinery (Colley, 1976).

Figure 17 shows gold production since gold was first mined in Fiji, and Figure 18 the total precious metal production between 1980-89. The increase in production from 1984 came mainly from the Emperor Gold Mine and the increase in 1988 and 1989 is from added production from the new Nasomo mine.

The Emperor mine is an important contributor to the economy of Fiji. The mine is located on the northern part of the island of Viti Levu, Fiji's largest island, on the western rim of the Tavua Basin caldera. Gold mineralization is epithermal and largely structurally controlled. Gold occurs in quartz-gold telluride veins within three structural environments—flatmakes (dips less than 40°) which are extensive in area, steep shears (dips greater than 40°), and in shatter zones (ore formed at intersection of two or more steep shears and a

flatmake). Fracture zones were the accompaniment to caldera collapse and have provided focus for the mineralization which was produced by resurgent volcanic activity.

Gold mineralization occurs in discrete veins in basalts and to a lesser extent trachybasalts, and is usually surrounded by very narrow zones of intense hydrothermal alteration. Mineralization varies in width from millimeters to tens of centimeters. The major gangue minerals are quartz and carbonate. Gold-silver tellurides, native tellurium, native gold and gold-bearing pyrite are the ore minerals. Rare native silver also occurs.

Cumulative historical mine production of the Tavua goldfield to the end of 1989 was 4.3 million oz. About one third of this production has come from open pits.

Recent Developments/Gold Production

Gold mining is being carried out at Vatukoula and Nasomo, both located within the Tavua Gold Fields. The Emperor Mine treats ore from both Vatukoula and Nasomo. The mine currently mills some 600,000 tonnes of ore per year. During 1989, the company treated a total of 604,827 tonnes of ore, producing 135,733 oz (4.2 tonnes) of gold and one tonne of silver compared to 564,779 tonnes of

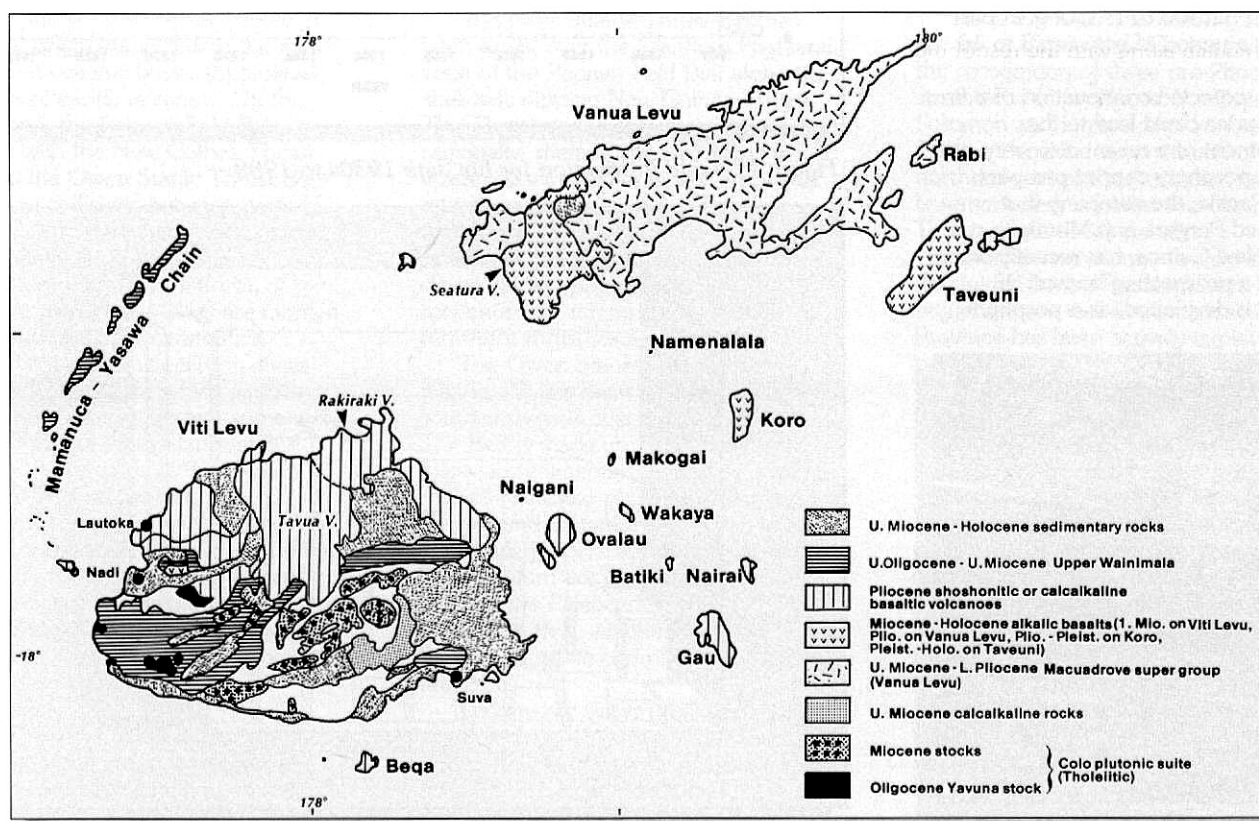


Figure 16. Generalized Geology of Fiji (after Rodda in Kroenke, 1984).

ore producing 137,420 oz (4.3 tonnes) of gold in 1988.

In 1989, gold and silver ranked second in value among the country's exports. The value of gold for the year was F\$75.8 million compared to F\$84.5 in 1988, and contribution of gold to Fiji's GDP was approximately 2 per cent. This decrease in value is the result of the fall in gold price rather than a significant decrease in gold production.

At Vatukoula, gold production for the year ending 1989 decreased from 89,300 oz to 72,178 oz as a result of extremely heavy seasonal rain which caused flooding at the lower levels of the mine. Openpit mining was increased to offset the loss. Proven recoverable ore stands at 1.2 million tonnes at 6.4 g/t.

The Nasomo deposit was discovered in 1985. This deposit is estimated to have 300,000 tonnes of recoverable ore with 14 g/t gold.

Future Outlook

The Emperor Mine at Vatukoula has been in production for 55 years and published ore reserves are equivalent to another eight years production. There is scope for increased ore reserves at Nasomo. Of the other prospects under exploration, the Mount Kasi prospect on the island of Vanua Levu is likely to be developed. The mine, if developed, is envisaged to be small scale producing less than 32,000 oz (1 t) of gold per year for a period of between 5 to 10 years.

The expected continuation of a firm copper price could lead to the development of a recent discovery, the Namosi porphyry copper prospect. Placer Pacific, the company that developed Porgera and Misima in Papua New Guinea, has recently been granted a prospecting licence. If Namosi is developed, as a porphyry



Wire Gold, Emperor Mine

copper-gold mine, it will be a significant development by world standards. The size of the Namosi deposit— 500 million t of 0.49 per cent copper and 0.16 g/t gold and 1 g/t silver, is in the size range of the Bougainville deposit, though with a lesser precious metals content. In 1979, when the pre-feasibility was undertaken, mine construction was estimated to be around F\$1 billion. A newly discovered prospect, the Cirianiu Prospect in Vanua Levu, showed extensive intersections (50 m) of low grade gold mineralization. The holder of the prospect, Placer Pacific, is currently evaluating the area by further drilling.

Fiji maintains mining legislation that will continue to attract international mineral exploration activity. A new constitution was adopted in Fiji in late July 1990, which provides for the vesting in the state of the ownership of unextracted minerals and provision of mineral royalties to be payable to the landowner. The previous constitution provided that all mineral royalties be paid to the state.

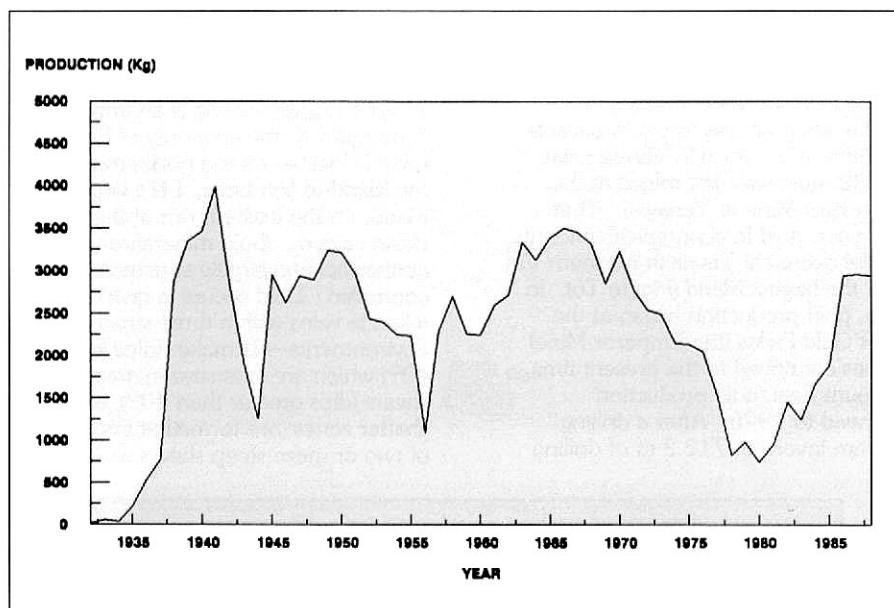


Figure 17. Gold Production for Fiji, late 1930s to 1988.

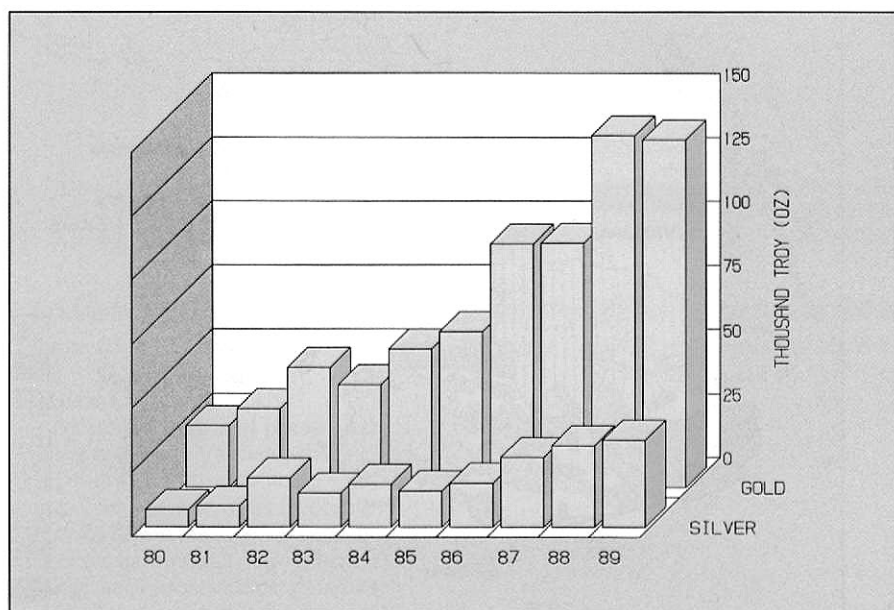


Figure 18. Total Precious Metal Production, Fiji, 1980-89

Geology of the Countries

PAPUA NEW GUINEA

Papua New Guinea straddles two large plates and as an obliquely convergent collision zone its geology reflects this (see especially Abers & McCaffrey, 1988; Carman & Carman, 1990; Kroenke, 1984; Rogerson et al., 1988; Rogerson and McKee, 1989; Smith, 1990).

The southwestern part, the Fly Platform, is foreland on the Australian craton (Figure 19); the remainder is the New Guinea Orogen (fold and thrust belts, translated terranes, island arc assemblages). The exact position of the boundary is not known, but has been placed at the Papuan Thrust. The Fly Platform (Rogerson & McKee, 1989) is a broad lowland, composed of flat-lying to gently dipping Mesozoic to Recent continental marginal clastic sediments, underlain by Paleozoic metamorphic and granitic rocks of the Indo-Australian plate.

The New Guinea Orogen (Rogerson et al., 1988) consists of variably deformed sedimentary, metamorphic, intrusive and volcanic rocks, mostly of island arc origin but including the rocks of remnant oceanic basins (ophiolites) and pods of exotic terranes. On the main island, the Papuan Fold Belt together with the New Guinea Thrust Belt, and the Owen Stanley Thrust Belt reflect past collisions between parts of island arcs and detached exotic portions of continental Australia with the northeastern edge (Fly Platform) of the Indo-Australian plate. They are marked by extensive areas of ultramafics. Pocketed between the collision zones are exotic terranes for which various origins have been suggested; some were derived from the Australian foreland (Rogerson & Hilyard, 1990; Pigram & Davies, 1987); others may be entrapped seafloor/oceanic crust. A group of shoshonitic volcanoes stud the southern highlands, probably derived from an ancient subducted slab that was lost following collision between New Guinea and the Outer Melanesian arc system with its accompanying microplates.

The Papuan Fold Belt (Figure 19) has been divided into a westerly Southern Highland zone and an easterly Aure Trough zone. Relatively open folds and shallow thrusts trend 300-330



Gold panner, Mt Kare

degrees. The Southern Highland zone is made up mainly of thick Miocene carbonate-dominated sequences. The Aure Trough zone comprises a thick sequence of Cretaceous to Pliocene volcanoclastic sediments, volcanics and carbonates.

The New Guinea Thrust Belt has been thrust over the Southern Highland zone of the Papuan Fold Belt along the shallowly-dipping New Guinea Thrust. The Thrust Belt is composed of regionally metamorphosed Neogene volcanoclastic sediments, volcanics and intrusives (Davies, 1980). The metamorphics are made up of a slate, schist and gneiss complex, sometimes showing examples of inverse metamorphic zoning that is thought to represent thrust stacking.

The Owen Stanley Thrust Belt (Figure 19) has been thrust southwestwards over the Aure zone. The Belt is made up of Cretaceous to Miocene sedimentary and basic volcanic rocks. The older rocks are deformed, cleaved and metamorphosed whereas the Miocene rocks are only deformed. These in turn are overlain by thrust slices of the Paleocene Papuan Ultramafic Belt, which include the Sadowa Intrusive complex near Port Moresby.

Tertiary arc system rocks are best preserved on the northern borders of Papua New Guinea and offshore on New Britain, New Ireland and Bougainville, and collectively known as the Melanesian Arc. This is, of course,

part of the general Melanesian arc system. New Ireland and Bougainville are an integral part of the Solomon Islands portion.

Stratigraphy

Recent work by the Geological Survey of Papua New Guinea has led to the recognition of three pre-Pliocene stratotectonic provinces: the Papuan, Solomon and Finisterre provinces. The Papuan Province covers much of the northern part of the Australian cratonic basement and contains Mesozoic and Tertiary sediments, including volcanolithic sediments. Areally it is dominated by the Papuan Basin. The sequences are well known because the Province has been actively explored for petroleum.

The Solomon Province consists of thrust sheets of Late Cretaceous and Paleocene oceanic crust that once formed the floor of the Solomon Sea to the north and east of the Papuan Province. Oceanic crustal rocks, ultramafics with ophiolites, basalts, dacites, and gabbros are overlain by hemipelagic carbonate sediments. This association is the Papuan Ultramafic Belt of Davies (1977) and Davies & Smith (1971), in turn part of the Owen Stanley Thrust Belt (Figure 20). There are a number of classic ophiolite sequences in the Solomon Province - the Marum, April and Uyaknji Complex and the Sadowa Ophiolites.

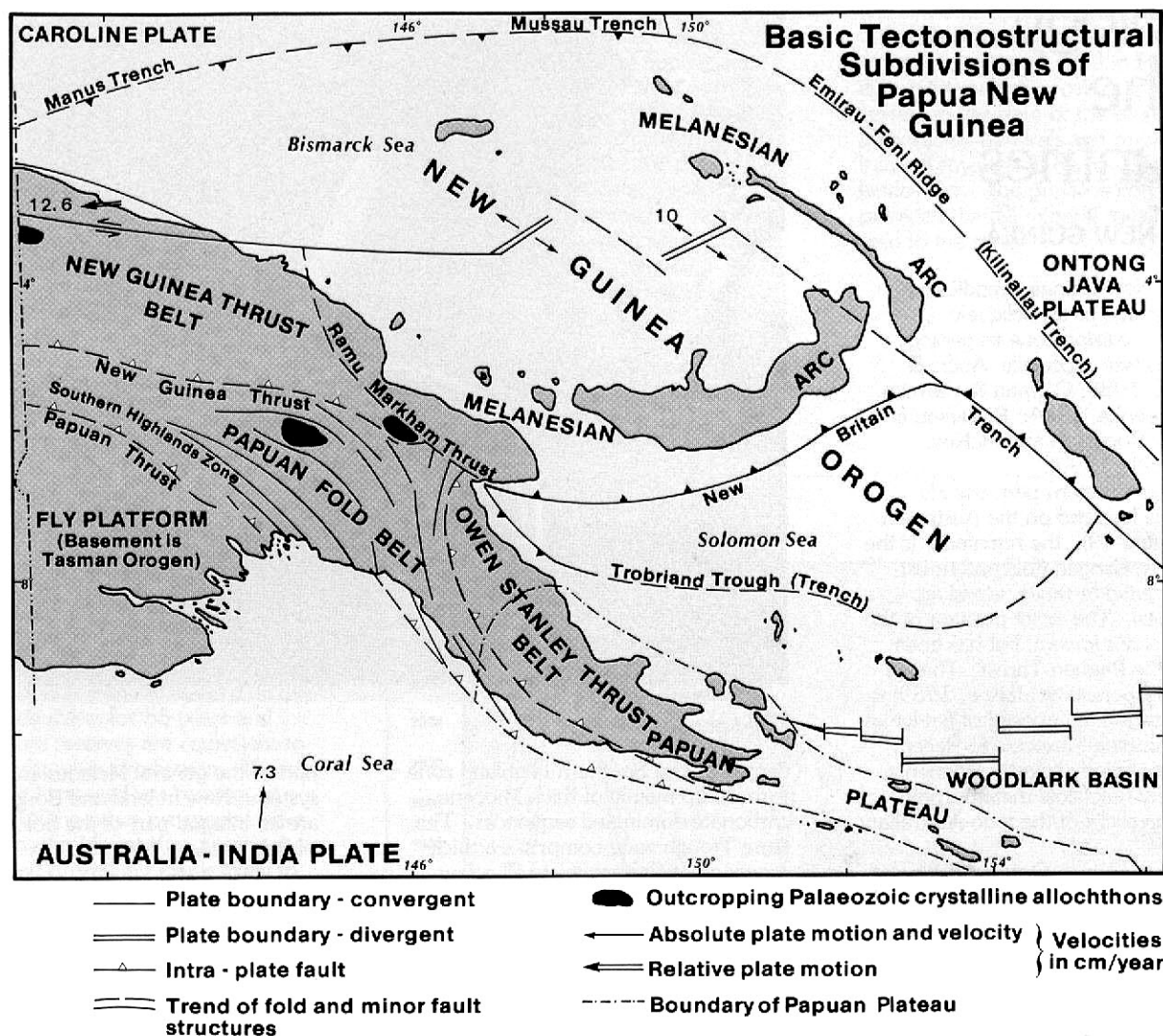


Figure 19. Tectonostratigraphic subdivisions of Papua New Guinea (after Rogerson & McKee, 1990).

The Finisterre Province (northern coastal New Guinea) consists of a newly-dismembered Paleogene-Quaternary island arc system that includes the collided Huon-Finisterre terrane and the offshore islands of New Britain, Manus, New Ireland and Bougainville. As said above, these last three islands have a geological continuation in the Solomon Islands. They are made up of arc pillow lavas, volcaniclastics, basaltic andesites, gabbros, ultramafic pods, calcalkaline basalts and andesites, diorites and volcanolithic sediments and reefal carbonates. Figure 20 illustrates the generalized geology and locates the major mineral deposits.

Chronology

The chronology of geologic events is illustrated in Table 3; this summarizes the major events that took place since the Paleocene (after Kroenke, 1984).

Igneous Rocks

The oldest known igneous rocks in Papua New Guinea are metavolcanics from the Fly Platform, but the bulk of igneous rocks date from Late Triassic to Recent and were generated during the evolution of the New Guinea Orogen. A significant proportion are present as fragments of obducted oceanic or marginal sea floor in the central cordillera and to the east — part of the Papuan Ultramafic Belt (Davies, 1977, 1980; Davies & Smith, 1971). Widespread island arc intrusions and volcanism formed the arc system of the Finisterre Province. Calcalkaline intermediate-acid plutons of late Oligocene age were emplaced in central-east New Britain; they host porphyry copper mineralization.

In the Late Oligocene/Miocene, volcanism took place at the then southwestern margin of the New Guinea Orogen. Marine and subaerial volcanism, accompanied by batholithic

and smaller intrusions, occurred along almost the entire length of the arc, from the Irian Jaya border to about 100 km SSE of Port Moresby. Extensive mineralization is associated with these intrusions, notably Porgera, Frieda River and Yandera (copper-gold), and Wafi (gold). Related igneous activity occurred on the islands east of Papua so that base and precious metal mineralization occurs at Woodlark and Misima Islands.

During the Pliocene (and especially in the early Pliocene) volcanism with accompanying intrusions was widespread throughout the New Guinea orogen and on the northern part of the Fly Platform. Nine Pliocene/Holocene volcanic provinces are recognized by Johnson et al. (1978): Fly Highland, Eastern Papua, Dawson Strait, Western and Eastern Bismarck arcs, Admiralty Islands, Rabaul, Tabar-Feni island group, and Bougainville (the activity extended southeast into Solomon

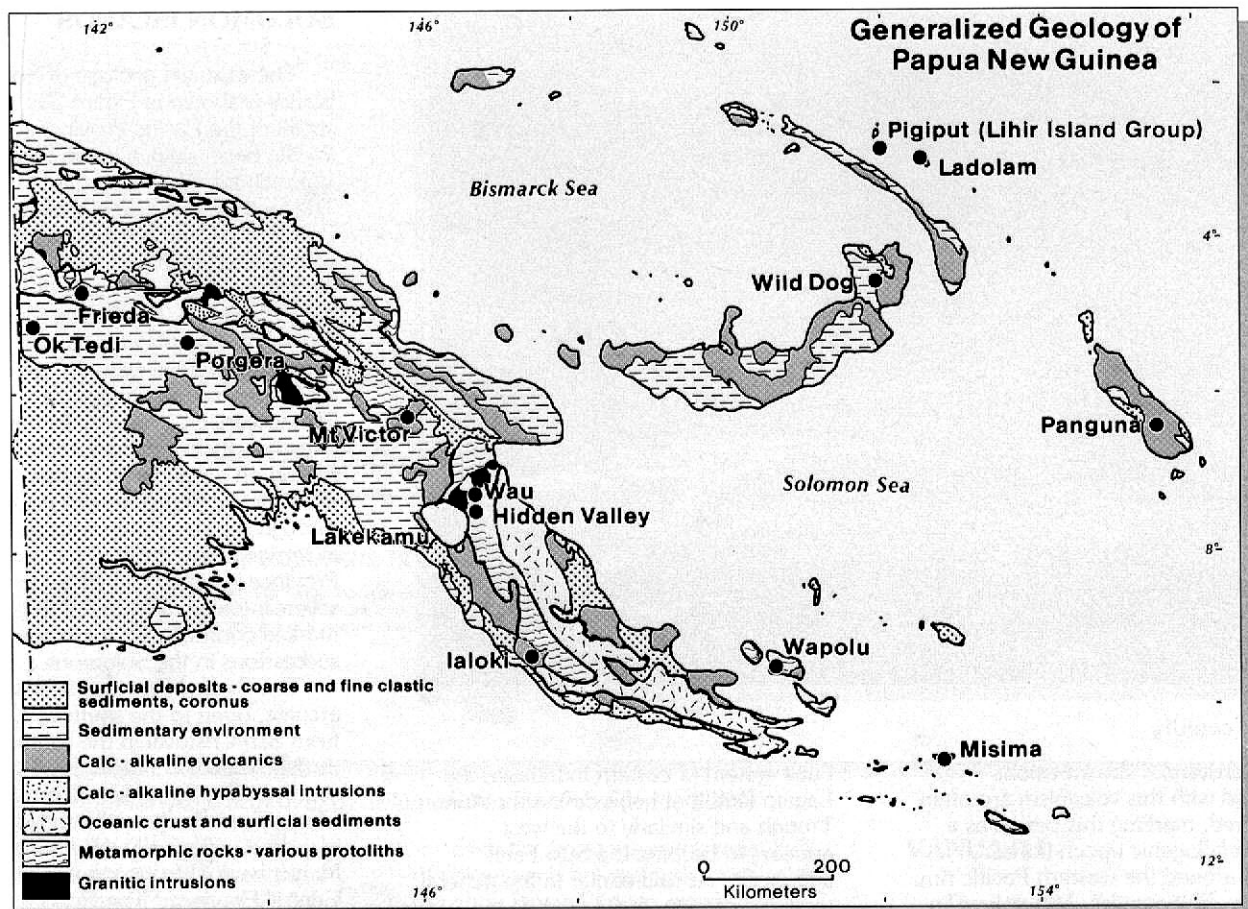
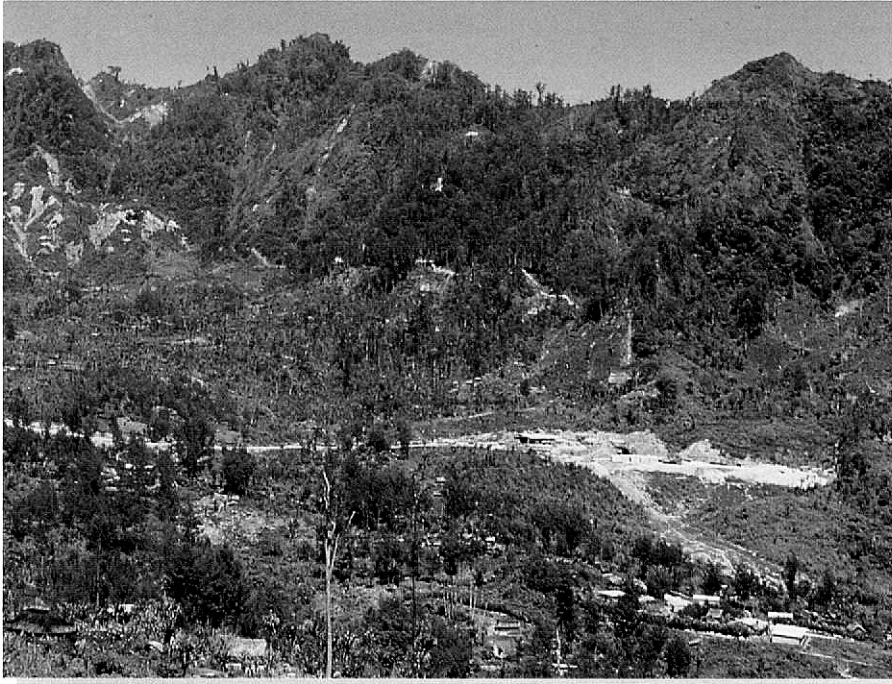


Figure 20. Generalised Geology of Papua New Guinea with locations of major mineral deposits (after Rogerson & McKee, 1990).

Chronology of geologic events in the Papua New Guinea area

Epoch	Time (Ma)	Northern New Guinea - New Guinea Mobile Belt / Papuan Peninsula / Auro - Muroby / Pocklington Trenches / Coral Sea Basin	Huon Peninsula / S.E. New Britain, Manus, and New Ireland / Manus / Matthias - Kilauea Trench	New Guinea Mobile Belt / Papuan Ultramafic Belt / Wewak - Trobriand Trenches	N.W. New Britain, Tabor - Feni Is. / New Britain Trench / Bismarck Sea - Woodlark Basin
Pleistocene				Reactivation of New Guinea Trench; Volcanism in New Guinea Highlands.	Collision of Schouten - New Britain Arc with Northern New Guinea.
Pliocene	5				Manus and Woodlark Basin dilation.
	10			Subduction ends along Wewak - Trobriand trench segments.	Initiation of New Britain volcanism.
	15		Adelbert - Finisterre Sarungaged - fragment of West Melanesian Back Arc impinges on New Guinea Trench.	Intrusive activity along New Guinea Mobile Belt (New Guinea Arc).	Tuff deposition in New Ireland.
	20			Emplacement of ultramafic sills in Ramu and South Sepik areas.	Formation of New Britain San Cristobal Trenches.
	25		Subduction ends. New Britain Intrusives emplaced.		
	30		Tinian Laves erupted on Manus Is.	Ambunti, Gwin, and Raindi metamorphic event; formation of New Guinea Trench.	
	35		Lemau Intrusives emplaced (New Ireland).		
	40	Subduction ends. Bewani - Torricelli igneous activity.	Jaula Volcanics erupted on New Ireland.		
	45	Overthrusting of Papuan Peninsula by ultramafics as Papuan Plateau and Kubor Anticline encounter trench.	Formation of West Melanesian Trench.		
	50	Formation of subduction melange in Papuan Trench.			
	55	Tonalites intrude Papuan Ultramafic Belt (Subvolcanic plutons).			
	60	Formation of Papuan Trench.			
	65	Formation of Coral Sea Basin.			
	70				
	75				
	80				
	85				
	90				
	95				
Late Cretaceous					
Senonian					

Table 3. Cenozoic geological events in the Papua New Guinea area (after Kroenke, 1984)



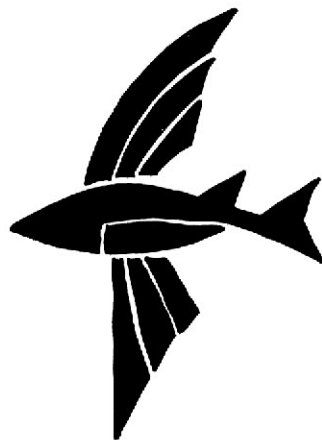
Porgera country

Islands territory). The intrusions associated with this volcanism are often mineralized, marking this period as a major metallogenic epoch (it has parallels around the western Pacific rim, e.g. in the Philippines). Mineralization occurs in porphyry copper and gold deposits at Mount Fubilan, the Ok Tedi Mine (both in the west), and Panguna on Bougainville; in gold-bearing porphyries at Hidden Valley and Wau (Lowenstein, 1982); in gold-bearing intrusives and volcanic rocks at Lihir island; and in gold-silver-telluride veins at Wild Dog on the Gazelle Peninsular, New Britain.

Structure

Folding in the sequences of the Fly Platform and thrusting associated with collision in the New Guinea Orogen have already been mentioned. The folding is essentially Jura-type folding over the Australian craton basement, broken by imbricate slicing. Thrusting is shallow angle with the overthrust blocks moving in a southerly direction. The thrust blocks are themselves broken by normal faulting following on block uplift. These vertical block movements in turn reflect, to a strong degree, the ubiquitous presence of strike-slip faults. The standard geological map of Papua New Guinea shows a plethora of faults, parallel and subparallel to the long axis of the island. This fault picture is a minimum one. Some of the faults are extremely long and deeply penetrating e.g. the Ramu-Markham Fault complex and its extensions west to become the Sorong

Fault system of eastern Indonesia; the Lagaip fault that helps define the Aure Trough and similarly to the west appears to become the Sula Fault (Figure 8). As said earlier in the general tectonics section, these great faults complexes have had a controlling influence in the emplacement, and probably the nature, of the major mineralized intrusions in Papua New Guinea.



SOLOMON ISLANDS

The essential geology of Solomon Islands is shown in Figure 21. One can speak of the Pacific Province (on the Pacific Basin side), Central Province and Volcanic Province (Coleman, 1966). The tectonic distinction between the Pacific and Central Provinces is debated, but there are clear, persistent, stratigraphic and structural differences between them. The Pacific Province, represented by Malaita, can be correlated in detail with the succession on the submarine Ontong Java Plateau. The succession is essentially made up of pelagites, including basal radiolarites, resting on ocean basin basalts. There are sporadic intrusions of basalt midway through the succession with an increase in terrigenous content. The Pacific Province is highly faulted but is also severely folded, a feature that is in marked contrast with the other successions in the Solomons.

The Central Province is broadly arcuate, open to the southwest. It runs from San Cristoval in the southeast, through Guadalcanal, Florida, southwestern Santa Isabel, most of Choiseul, to Bougainville and Buka islands. Geologically, New Ireland and Manus have a strong relation to the Central Province. The Central Province is a structural high — the Solomon High of Coleman (1989) or, in part, the North Solomon Ridge of Kroenke (1984). The succession for the Central Province is varied. Essentially, basement is made up of mixed arc/ocean floor igneous rocks, including pillow lavas, basaltic andesites, dolerites, gabbros, greenschists, andesites and ultramafics (most of the last are serpentinised). The sediments above this basement commonly begin with substantial thicknesses of algal foraminiferal reefal calcarenites, often with a volcanic mix. But the dominant sediments are composed of volcanoclastic wackes, often turbiditic, but also chaotic, with a high clay content. Such wackes often show signs of redistribution but in other sequences, often close by, the sediment appears to have been derived from fresh tuffs, or subaerially from nearby volcanoes, and laid down with speed and finality. They vary in grain size from clays, rare shales, clayey sands to rudites and olistostromal deposits; the latter are quite common in the succession. Deepsea pelagitic limestones occur in thin layers, over limited areas, sometimes without any volcanic detritus but contiguous laterally and vertically to high energy wackes. Their presence is explained by extremely vigorous vertical movement of discrete fault blocks (Coleman et al., 1988).

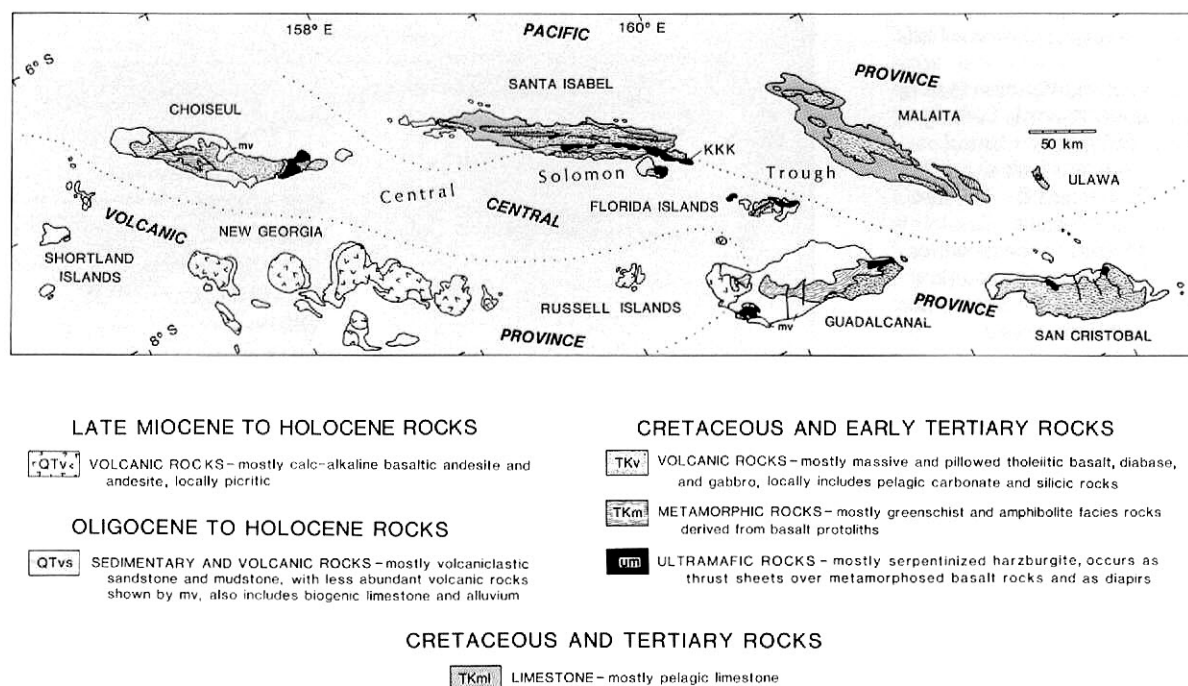


Figure 21. Simplified geological map of Solomon Islands (from Wells, 1989).

Structure in the Central Province is dominated by a system of high angle faulting with preferred trends of WNW (parallel to the trend of the islands), NNW and NNE. Folding is rare, and where present, folds are incidental to faults (e.g. drape folds). Major faults appear to shape the islands, e.g. the boundaries to southwestern and southern Choiseul; the southern Guadalcanal coastline. It is likely that the whole of the Central Province is fault-bounded and has been so for a large part of the Tertiary, although equally likely, its configuration in detail has changed through that time. Large-scale strike-slip faulting has played a considerable role in the development of the Solomon Islands (Coleman, 1991).

The Volcanic Province spans the chord across the arc of the Central Province, ending at the western end with a line of volcanoes that forms the spine of Bougainville, and to the east, ending with old volcanoes at the western end of Guadalcanal (including offshore Savo). The Province is probably less than 5-6 Myr old and is made up of a set of volcanic piles, linked by their extrusives, and in parts coalesced to form large islands e.g. New Georgia Island. The intrusives and lavas are chemically highly varied with anomalous features that reflect a complex history. They include oceanic basalts, arc-type basalts, picrites, gabbros, dacites and subsidiary calcalkaline andesites and diorites.

Even the positions of the main bulk of volcanoes is anomalously close to the trench; a few volcanoes are absolutely anomalous and situated on the ocean side of the trench. The volcanoes on Choiseul are made up of calcalkaline andesites and their location is difficult to relate to any present-day subduction zone.

The igneous activity that produced the Volcanic Province is economically important. This activity followed on subduction reversal and includes the porphyry copper deposits of Panguna on Bougainville, and of Kolo'ula on Guadalcanal, as well as other unproved and untested prospects.

VANUATU

The country of Vanuatu occupies most of the New Hebrides arc. In this arc, the provincial division is analogous to that of the Solomons, made up of: the Western Belt, the Eastern Belt and the Central Volcanic chain (generalized geology shown in Figure 22; for detail, see Macfarlane et al., 1988). The Western Belt consists of a 26-km thick crustal wedge along the western edge of the arc massif. It is exposed on the Santa Cruz Group (main island, Nendo - part of Solomon Islands territory) at the northern end, Torres group, Espiritu Santo and Malekula in the south. The basement rocks are made up of arc basalts, basaltic andesites, andesites and their concomitant clastics. Gabbro and diorite are minor. On Malekula, the sedimentary succession begins with deepwater clays rich in fine volcanic detritus, but elsewhere with varied volcanoclastics including turbidites, olistostromes and other chaotic sediments, and calcarenites that range from algal-foram reefal types to highly volcanic lithic calcarenites. Reefal mounds and lenses are common in some areas e.g. Espiritu Santo. Following a break in deposition during the Late Miocene, calcilutites and hemipelagic sediments are more frequent, interspersed with conglomerates. This sort of sequence reflects varying energy levels that followed on vigorous vertical

movements. Final uplift is represented by elevated limestone plateaus that surround Malekula and cover the whole of eastern Santo.

The structure of the Western Belt is dominated by dense, hi-angle faulting and, as with the Solomons' Central Province, the islands are fault-shaped. Fault trends NNE, NE and E. The last direction has special tectonic significance; it is linked to the elevation of the Western Belt, especially marked in Santo, and follows on the attempted subduction of the d'Entrecasteaux Ridge.

The Eastern Belt succession reflects its ancient forearc position. The Belt consists of Maewo and Pentecost (Raga), both narrow, slab-sided horst blocks. The succession begins with deepwater volcanoclastics, including breccias and conglomerates, associated with subaerial and submarine arc basalts and intruded by basic sills and dikes. The ultramafics and serpentinites on Pentecost, part of an ophiolite suite, have been emplaced diapirically into these younger rocks. They have a minimum age of Early Oligocene. The overlying sediments are volcanoclastic, turbiditic and include olistostromes and calcarenites. They are as old as latest Oligocene/earliest Miocene and at their base include rudites with igneous and derived Upper Eocene limestone clasts that bear comparison with Fiji equivalents (but not with rocks of the Western Belt). The succession is marked by sediments increasingly calcareous and topped with a cap of reefal limestone.

The structure is dominated by N-S faults but W-E and SW-NE faults are also common. This system of faults has shaped both islands. They are steep-sided, flat-topped, elongate, narrow horst blocks, that have been uplifted during the recent geological past - perhaps within the last few hundred thousand years.

The New Volcanic Province roughly defines the axis of the arc massif. There are more than a dozen volcanoes with Utupua and Vanikolo at the north end, separated by a gap to the Banks group, then Aoba and Ambrym (the largest), Epi, Efate through Tanna and Aneityum to the south. Large fractures trending roughly W-E, orthogonal to the trench have influenced the siting and shape of the volcanoes e.g. both Aoba and Ambrym owe their position and shape to the Aoba and Ambrym fracture zones, respectively; they also control the siting of minor effusive centers on these islands. The build-up of the volcanic piles has shaped the intra-arc basins e.g. the division of the Central New Hebrides Basin into North Aoba Basin and South Aoba Basin.

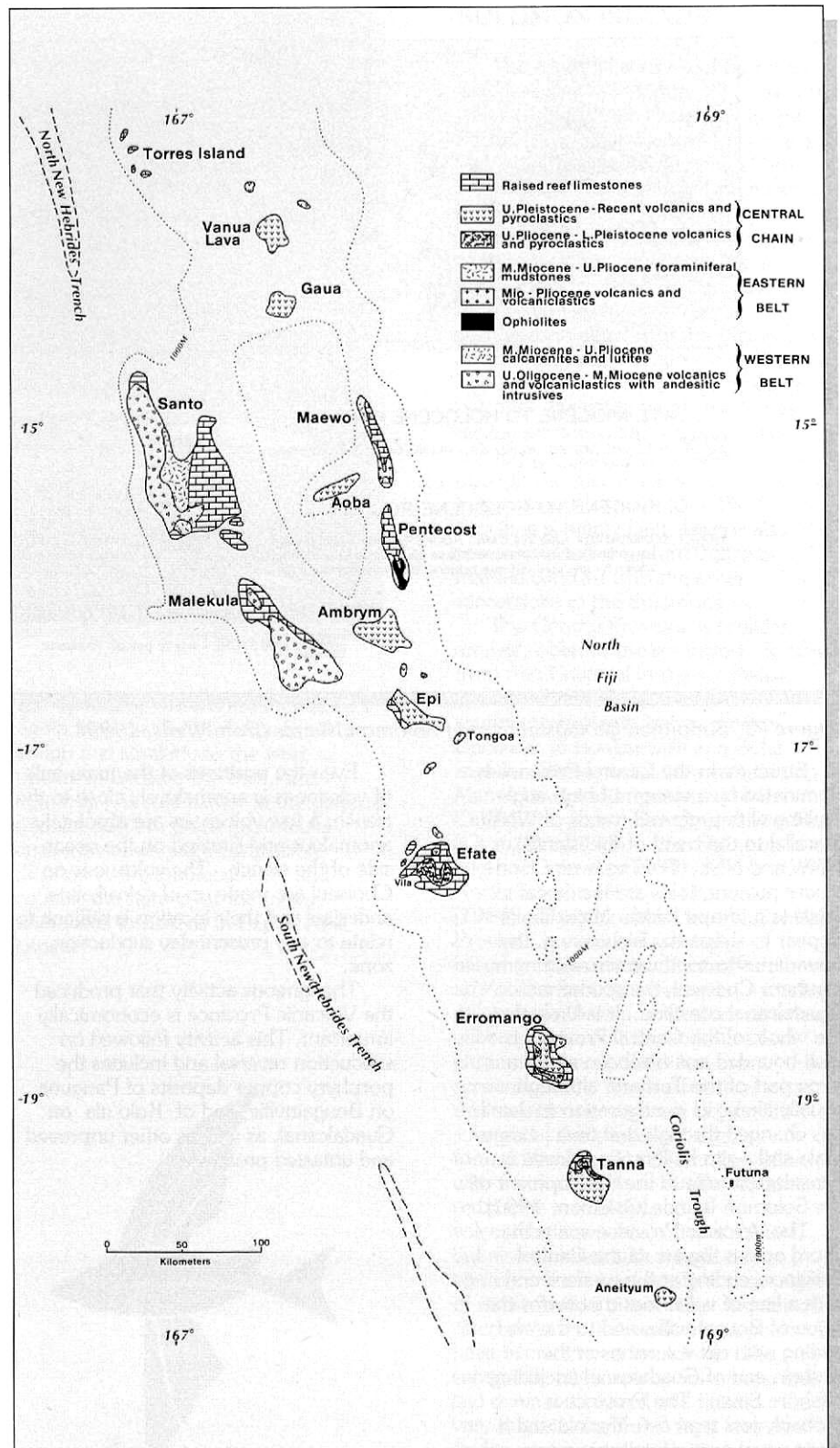


Figure 22. Generalized Geology of Vanuatu (after Carney & MacFarlane, 1978).

The Volcanic Province marks the initiation of new volcanism following subduction reversal and slab rollback and migration to the southwest of the New Hebrides arc at about 8 Myr (as outlined in the Regional Geology/Tectonics

section above). As with the Solomon Islands, arc crust in Vanuatu has undergone a complex history, the consequence of this subduction reversal (see Figure 23).

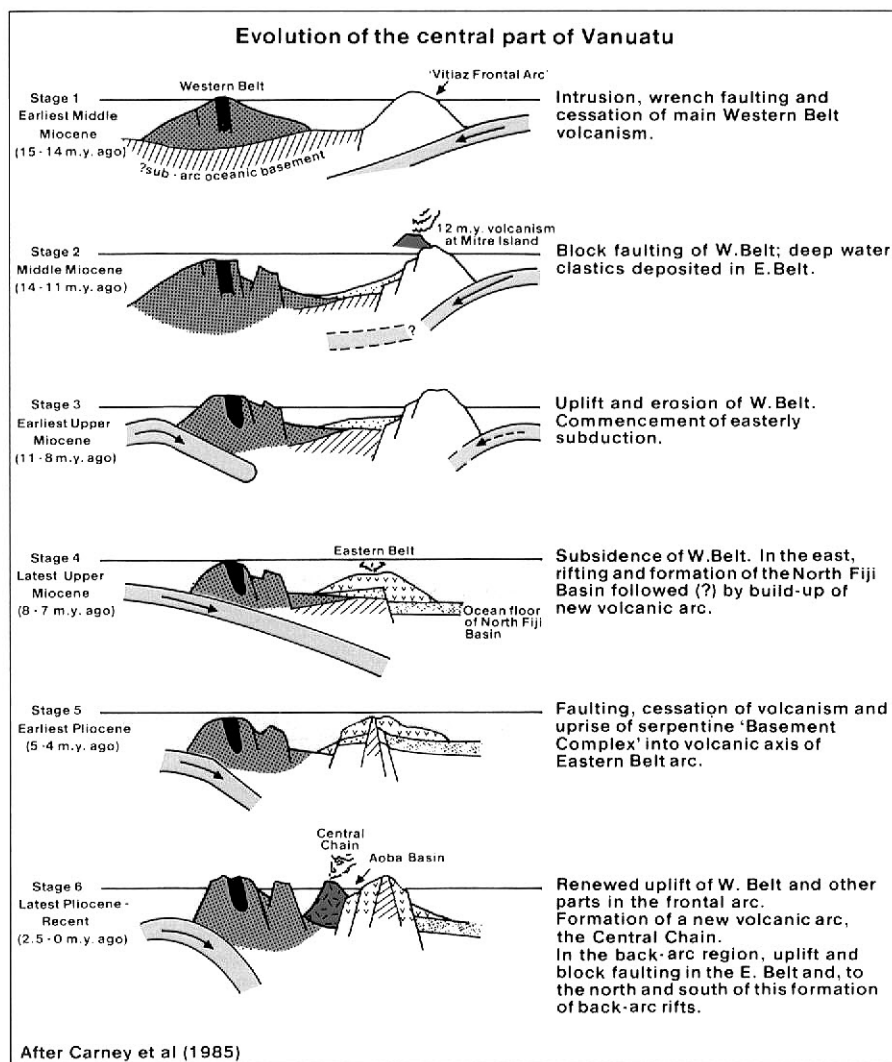


Figure 23. Evolution of the central part of Vanuatu.

Fiji

The Fiji platform carries the two large islands of Viti Levu and Vanua Levu, the two strings of small islands making up the Mamanuca and Yasawa groups to the west, and several volcanic islands to the south and east (Figure 24). The platform has been involved in the creation of the north Fiji Plateau and the Lau intra-arc basin, and has been rotated by the transformation of the Tonga trench to the old Viti'az transform/subduction zone. The rotation has been clockwise and then anticlockwise at various times.

Disruption brought about by intensive strike-slip movements along long, deeply-penetrative faults that gave expression to the apparent spiral rotation of the Fiji arc has broken the platform into a mosaic of fault blocks. Within this mosaic, adjacent blocks may bear little or no stratigraphic relation one to another. This mix of

disrupted autochthonous components, with at least several allochthonous ones, makes difficult the presentation of a coherent, unified account of Fijian regional geology.

The oldest dated rocks are foraminiferal/algal limestones, lacking coral, of Late Eocene age, that substantially overlie, but are interbedded with, or intruded by, massive and pillowed basalts, gabbroic stocks and pods, basaltic andesite volcanics and intrusives, and some rhyolitic epiclastics (see Rodda, 1991; Rodda & Kroenke, 1984; Rodda & Lum, 1991). Early Oligocene limestones (coralgal with subsidiary foraminifera) are at the top of this dominantly igneous sequence. These old rocks make up the Yavuna Group, with a probable overall age of Eocene-early Oligocene, and which shows greenschist facies metamorphism (Figure 24). Geochemically, the older basalts are not typically arc-basalts but rather resemble those generated at mid-

ocean ridges; younger ones appear to be transitional to low-K arc tholeiites. The Yavuna Group is intruded by a large, quartzose tonalite/trondhjemite stock and by quartz-rich dacitic dykes (probably related and about 34 Myr old - see chronology of events, Table 4).

The rocks of the younger Wainimala Group are stratigraphically and structurally distinct from those of the Yavuna Group. They make up a composite of fault-bounded blocks (some of which may be allochthons) that consist of volcanic arc assemblages that range in age from Late Oligocene to Middle Miocene. They may show prehnite-pumpellyite to greenschist facies metamorphism. The older part of the general sequence is dominated by rudites and olistostromes, often polymict with basalt, dacite and minor limestone clasts. Some of the turbiditic sediments include shallow-water limestones of Late Oligocene/Early Miocene age.

In other areas, the Wainimala Group includes lenses and dykes of feldspar-rich dacites and andesites, usually massive but including some breccias, lavas and tuffs. They are thought to have belonged to the low-K arc tholeiite series but are now extensively metamorphosed to a greenschist level. Basalts are also common, both pillowed and massive, and not apparently related to the dacite bodies described. They appear to have mid-ocean ridge basalt affinities. Basinal sediments including turbidites and hemipelagites are associated with the basalts. They are usually quartz-free but include likely ash falls, redistributed shallow-water clasts and coralline and coral debris. This sedimentary sequence also includes gold-enriched mineralized manganese deposits, usually located along faults or in complex shear zones. These basinal rocks appear to have ages ranging from latest Oligocene through early Middle Miocene. The sequence becomes sandier toward the top.

Late mid-Miocene and younger rocks

Fiji is rich in potential target rocks. The upper levels of the Wainimala Group are marked by patchily-distributed hornblende andesite dykes, by wackes and shallow-water limestones of probable mid-Miocene age, the latter capping the Group. The general sequence lacks evidence of sedimentation or volcanism from mid-Miocene through early late Miocene. But the intrusions of plutons - the Colo Plutonic Suite (see Table 4) is a prominent feature. This intrusive event may have considerable economic significance. It is an expression of the

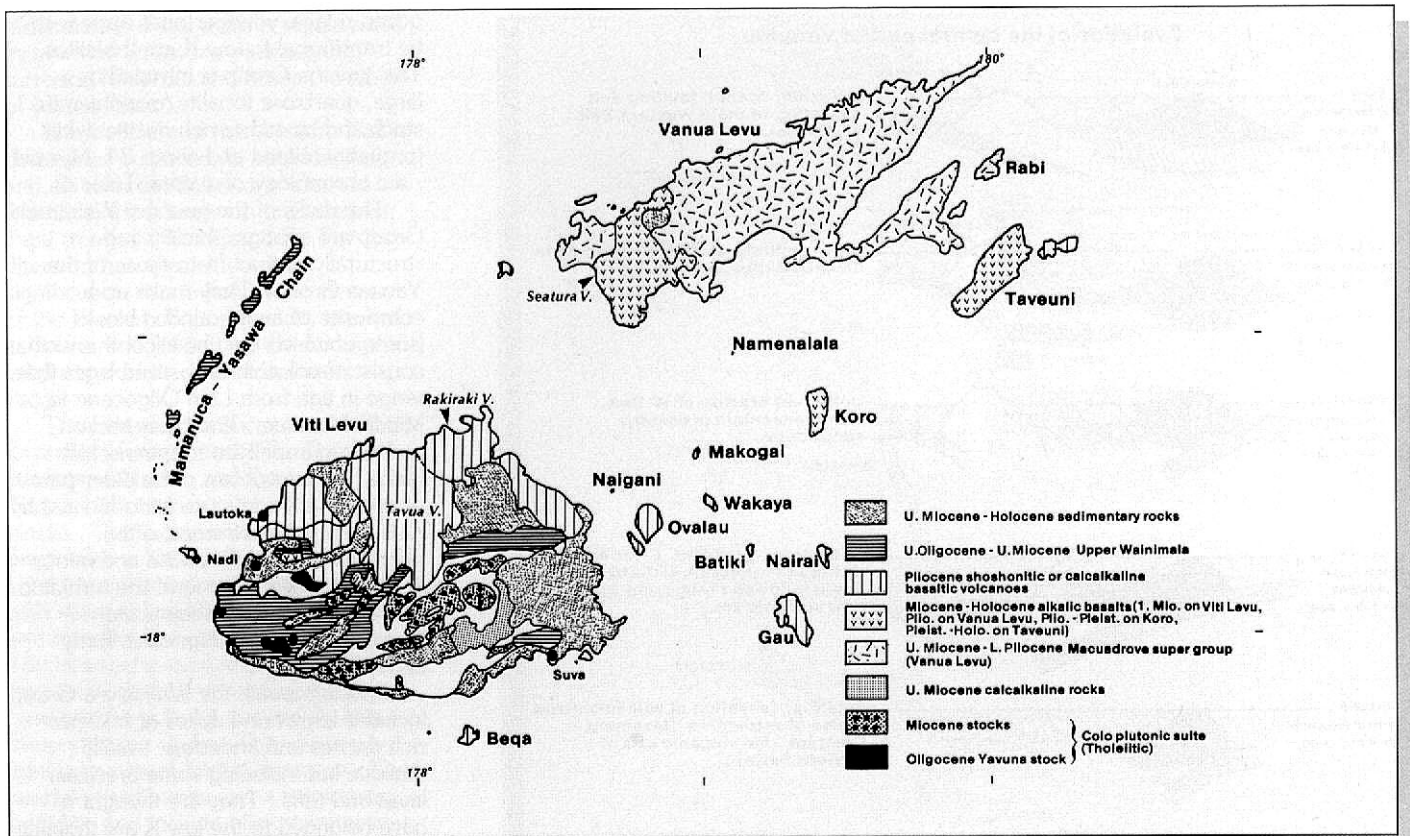


Figure 24. Generalized Geology of Fiji (after Rodda in Kroenke, 1984).

Colo Orogeny, the result of unknown tectonism but possibly linked to the opening of the North Fiji basin. Most of the folding and faulting of the Wainimala Group occurred during the orogeny. The intrusive gabbros and tonalites occur in a zone that stretches from southwestern Viti Levu east to the edge of the Fiji Platform. Associated greenschist facies metamorphism is widespread, with stronger deformation on some plutonic contacts. The oldest accurate date for one of the plutons is 12.46 Myr \pm 0.51 Myr (the Wainivalau Stock, north of Namosi). The youngest activity may be as young as 7 to 8 Myr. An overall effect of the Colo orogeny was the regional uplift of the old terrane that is now a large part of the southern half of Viti Levu. During the waning stages of the Colo Orogeny, large scale sedimentation resulted in a number of sedimentary groups that unconformably overly Wainimala rocks in areas of both western and eastern Viti Levu. These are Late Miocene sediments. Volcanism with the formation of breccias and subaqueous flows metamorphosed some of the sedimentary groups in western Viti Levu (Nadi and Navosa Groups) and andesitic plugs were injected. The present-day Yasawa Islands chain resulted largely from the same submarine activity. These islands are mainly dacitic with minor andesites and

basalts; there is some mineralization, mostly copper. Extensive acidic volcanism formed the northeastern part of Vanua Levu. In the same area, boninitic lavas were erupted further northeast, but to the west, basalts, basaltic andesites, and minor andesites and other acidic rocks were erupted - making up the Macuadrovo Super Group. This arc volcanism continued until about 4 Myr ago.

Late Miocene - Recent volcanism is most marked on Viti Levu (Figure 24). Calcalkaline volcanism began about 6 Myr ago mainly in southern Viti levu; the Namosi Andesite is a major eruptive that also contains an intrusion that hosts the porphyry copper deposits. Shoshonitic volcanism began slightly later at about 5.4 Myr, producing volcanic edifices across the northern half of the island - the Sabeto Range, Tavua volcano (Emperor Gold Mine) and at least part of the Nakorotubu Range in the northeast. Activity continued for perhaps three million years. Penecontemporaneous calcalkaline volcanoes also formed in the same area, notably the Vatia and Rakiraki volcanoes. Over the same time span, shoshonitic rocks erupted to the south of Viti Levu, as on Vatulele and the island of Bega and other islands of the Bega lagoon (a caldera?). Kadavu to the south is also shoshonitic in large part. The islands east of Viti

Levu - Gau, Moala and Wakaya include shoshonites.

Sedimentation continued between the volcanic centers, notably resulting in the Suva Marl that has been accurately dated with time of deposition between 5.2-3.2 Myr ago. There were also extensive tholeiitic and calcalkaline intrusions on Vanua Levu (Macuadrovo Super group). Most of the small islands east of Viti Levu, including the those of the Lau Group are made up of tholeiitic and/or calcalkaline volcanics.

Vertical movements accompanied the igneous intrusions. Pillow lavas of the Tavua volcano are now at 880 m above sea level, with the whole volcano tilted northwards. Much of Viti Levu has been uplifted. These vertical movements may be due to doming, but may also be due to a combination of doming and thrust-ramping of fault-defined blocks following on strike-slip movement.

Much of Vanua Levu had been elevated by the mid-Pliocene. With the uplift of western Vanua Levu, eruptions of alkali basalts occurred, resulting in the formation of the large Seatura shield volcano. This volcano is the main expression of the Bua Volcanic Group with ages ranging from 3.35-2.83 Myr.

The Lomaiviti Islands are volcanic, mainly basaltic and range in age from Late Miocene to Early Pliocene. The

Lau Islands are the visible parts of the Lau Ridge, once part of the more general Fiji arc but now a remnant arc behind the Tonga arc. Pyroxene andesite is the main rock type, with subordinate basalt, ranging in age from Late Miocene to Pliocene. Alkali basalt makes up the Mago Volcanic Group, north and central Lau, of late Pliocene-Quaternary age.

Kadavu, south of Viti Levu is the product of subaerial volcanism, with basal basic lavas in the northeast about 3.4 Myr old and becoming more acidic and younger to the southwest (Late Pliocene- mid-Pleistocene). They are rich in potash and are probably offshore expressions of the shoshonitic phase of igneous activity so marked on Viti Levu.

Fault Systems and Search Tactics

In a previous section (p.7), it is proposed that complex crust with complex history is consistent with the emplacement of high-level intrusions with high metal content. In this section, the emphasis is on a neglected aspect of the search for metals in arc systems, especially gold, silver and copper, namely, the powerful role played by strike-slip faulting in the shaping of arcs

of the oblique convergence and the sporadic coupling of the Pacific Plate with the Australia-India Plate. As a boundary complex, these faults form a wide zone, up to 100 km wide, that stretches from Tonga to the Halmaheras in eastern Indonesia (Figure 8). The arcs that are spread along the boundary, especially Fiji, New Hebrides, Solomons and northern New Guinea, are split into a shuffling mosaic of blocks in which the greater part of the oblique component of motion is accommodated by a 'master' fault set. This master set may jump about through time. In western Indonesia, for example, the master set, at present, is the Sumatran Barisan fault system. In the Solomons, a past master set is

Epoch	Time (Ma)	Yasawa - Viti Levu / Kadavu / Lomaiviti Moala Group	Lau Group	Vanua Levu / Taveuni / Koro
Pleistocene		Island - arc volcanism on Kadavu, eastern Viti Levu, Naigani; subduction along Kadavu Trench.	Minor alkalic volcanism	Alkalic volcanism on Taveuni, Vanua Levu, and Koro; rifting of Natewa Bay.
Pliocene	5	Shoshonitic volcanism on Vatulele - Beqa, northern Viti Levu, Lomaiviti Group.	Island - arc volcanism in northern Lau Group.	
	10	Calc - alkaline volcanism eastern and western Viti Levu, Lomaiviti and Moala Groups.	Island - arc tholeiitic volcanism in northern Lau Group along the WNW New Hebrides Trend.	Island - arc tholeiitic and calcalkaline volcanism on Vanua Levu.
Miocene	15	Island - arc tholeiitic volcanism along Yasawa - Wainimala - Colo Plutonic Belt, Lomaiviti and Moala Groups.	Lau - Tongatapu volcanism along the Northerly Lau Ridge Trend.	
	20			
	25			
Oligocene	30	Vitiaz Arc volcanism producing Lower Wainimala Group.		
	35	Tonalite intrusion into Lower Wainimala Group (Viti Levu).		
	40			
Eocene	45			

Table 4. Geological events in Fiji over the last 40 million years (after Kroenke, 1984).

Mineralisation is common. To the east, Taveuni represents the final stage of Fijian volcanism and consists of alkali basalts erupted at many points along a northeasterly trending fissure. The youngest rocks are less than 2000 years old.

This period of intense igneous activity, spanning several million years, can be linked to the formation of the North Fiji Plateau, the migration to the southwest of the New Hebrides chain, and the rotation and slicing of the Fiji Platform.

formed at obliquely convergent boundaries, and, as a consequence of this, in the siting and form of high-level intrusions adjacent to the volcanic front and in the adjacent forearc. Strike-slip action is of special relevance in the search for ore bodies in Papua New Guinea, Solomon Islands, Vanuatu and Fiji, the countries that lie on the much-faulted Melanesian Boundary.

STRIKE-SLIP FAULTS IN ARC SYSTEMS

The Melanesian Boundary is for the most part marked by large and small strike-slip faults that are a consequence

represented by the dormant Kia-Kaipito-Korigole fault system: it has been supplanted by a poorly-defined fault system that runs roughly WNW-ESE south of Guadalcanal. In New Guinea, the Markham-Ramu, Lagaip-Sula and Sorong faults are among the masters (Figure 8).

Most faults within the complex are listric, with planes that undulate both in profile and along strike. Movement along such sinuous faults may result in transpressional and transtensional situations along strike and within the profile. In a composite of listric faults (and blocks) transtensional situations may persist to great depth and may

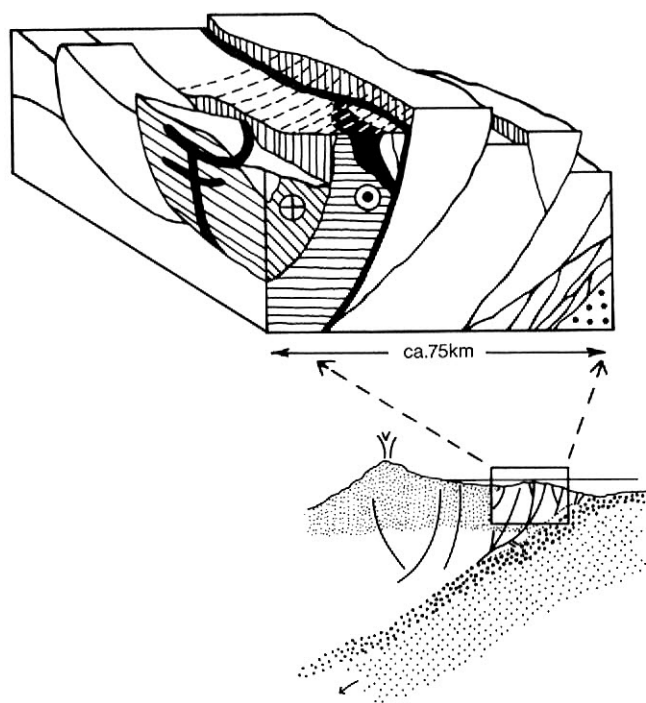


Figure 25. Profile model of a strike-slip complex at an obliquely convergent boundary with a growing island arc.

Because of the undulatory nature of the fracture surfaces, strike-slip movement results not only in relative translational and vertical shifts of blocks but also block rotations about both horizontal and vertical axes. High level intrusives (and their caps) may be tilted strongly to give misleading outcrop patterns (front left). Vigorous vertical movement create graben that can be filled speedily by superficial deposits so that young epithermal deposits can be effectively hidden from direct observation (center). The heavy fault trace is the master fault that is accommodating the current major stress.

even provide access for magma.

Large lateral shifts of fault-defined blocks accompany strike-slip movements within the fault complex. Individual blocks can be in sizes up to 50-70 km in largest dimension. The blocks may also be elevated or depressed and may be rotated about both vertical and horizontal axes (Coleman 1991; Geist et al., 1988) (Figure 25). The vertical movements may be extremely rapid (perhaps two kilometers per million years). Horizontal movements, parallel or subparallel to the boundary, may take place at rates of tens of kilometers per million years, so that portions of the forearc may be translated hundreds of kilometers along the boundary in quite a short geological time; in complementary fashion, the arc system may also receive split-off portions of other arcs (or split-off bits of continental margins). In the New Guinea area, for example, some of the western blocks, e.g. Wageo Island, may well have come from northeastern Australia. The central New Guinea Kubor block almost certainly did (Rogerson & Hilyard, 1990). The Kubor block was

transported, we believe, along the Lagaip fault complex, from the now-submerged Queensland Plateau, following on the opening of the Coral Sea. Many of the more exotic of the transported block movements have been documented by Pigram & Davies (1987). This Melanesian boundary is, as it were, a working demonstration of the way in which much of the Alaskan agglomeration of exotic terranes was formed.

The piecemeal slicing of arcs and shuffling of fault blocks has marked implications in the search for metal ore bodies.

We begin by proposing that hydrothermal deposits are a normal - even a necessary - part of arc development and that an arc that has reached the calcalkaline stage is producing hydrothermal deposits, epithermal ones in particular (for supporting literature see Henley, 1990; Sillitoe, 1989). The corollary is that the number found in an arc system reflects to an extent the intensity and effectiveness of geological exploration within the system. We have asserted that the presence and relative richness

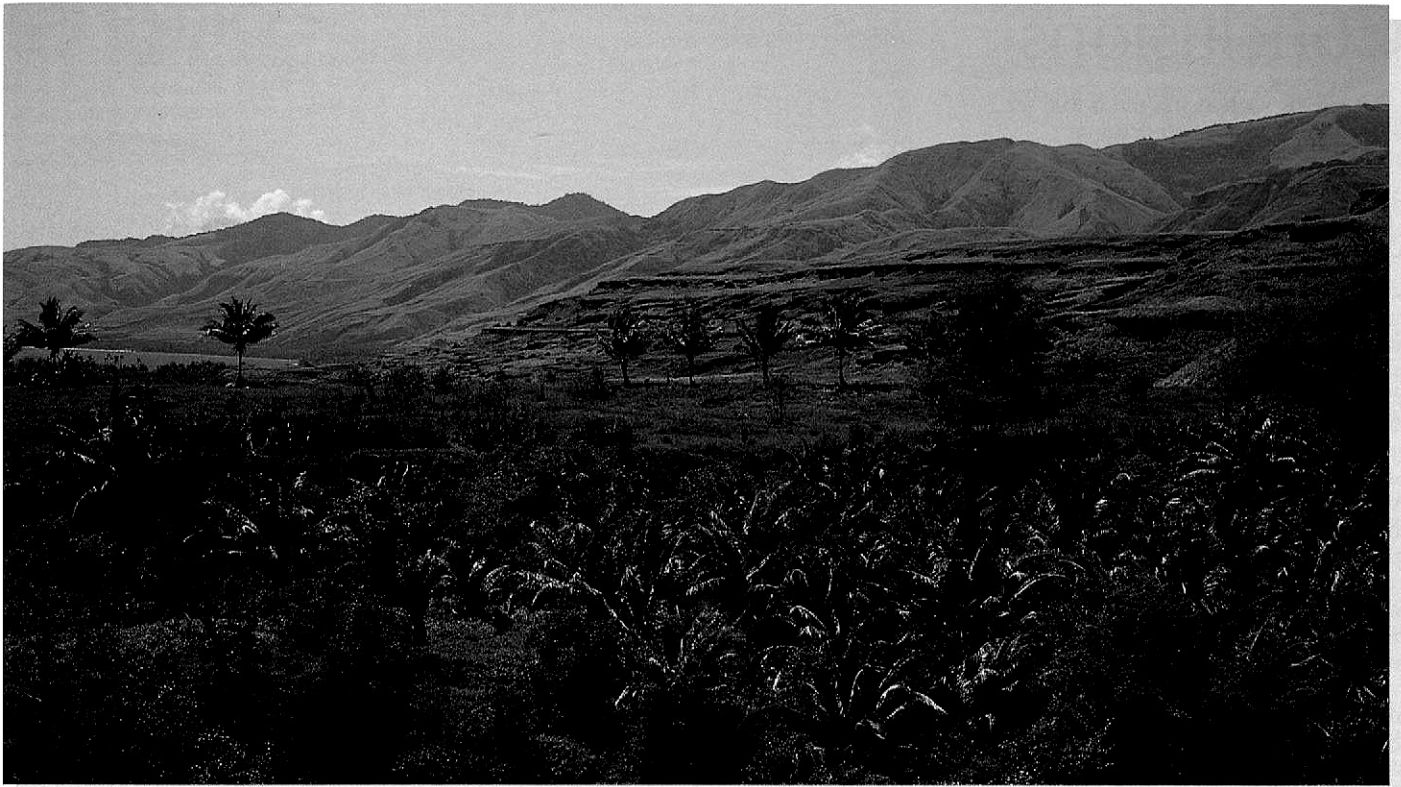
of ore bodies also reflect the complexity of the arc crust penetrated by the host intrusion. Crustal complexity reflects the complexity of the tectonic history of the arc (or arc segment), for example, arc reversal and strike-slip faulting following on oblique convergence. The role of strike-slip faulting is poorly appreciated, but is one we emphasise.

It is generally accepted that the cap of an epithermal deposit (with the richest gold content) is emplaced quite near the surface (but is not necessarily confined to a small vertical interval). After emplacement, the future value of a deposit may be greatly affected by the degree of erosion that the deposit has suffered, which in turn is linked to movements of the block containing the deposit. For example, rapid elevation with an increased rate of erosion can strip the cap before the explorer can get to it! While rapid vertical uplift can hasten the exposure and erosion of the deposit, downdropping can deepen the deposit and make it more expensive to mine. This is a negative effect, but shallow burial can be positive — the deposit can be preserved with a cover of surficial deposits. (Figure 25). The deposit may be veiled from surface discovery, and, if the cover is thick enough, may not give off a geochemical signature.

Rotation of blocks after emplacement of an epithermal body can tilt the deposit 20 or 30 degrees or more and lead to an ambiguous or truly misleading outcrop pattern (suggested in Figure 25).

The speed of these actions warrants emphasis. Block elevations of two kilometers in a million years are ordinary rates; rotation from horizontal to give dips of 25 degrees in one hundred thousand years is not exceptional.

Transtensional sites along large-scale strike-slip faults also play an important part in the positioning of intrusive bodies in arc terranes: they provide access for magma upwellings. This is especially true for faults conjugate to the master set, as illustrated along the length of the Barisan Fault (Sumatra) and Philippine Fault (Mindanao and Luzon). In the Solomons the confluence of conjugate faults and deeply penetrative large faults orthogonal to the trench appears to control the siting of stocks.



Stepped fault blocks, Huon Peninsula

STRATEGY AND TACTICS

As its core, a strategy for precious metals exploration in arc systems should aim squarely, if not exclusively, at those portions or segments of arcs that exhibit the most complex crust with a complementary complex tectonic history. In simple terms, such areas suggest themselves by the "difficult" geology and the difficulty experienced in making sense of the results of field mapping, and by the presence of "anomalies" both geological and geophysical. The igneous rocks especially will be characterized by wide variation in texture and composition (quite apart from the likely host intrusions) and may be in stratigraphically or structurally anomalous juxtaposition e.g. serpentinites bodies within turbidites, or ophiolitic wedges against rhyolite flows. These and other anomalies suggest disruption following strike-slip movement. In the western Pacific, late Cenozoic igneous rocks should be given special attention.

In island arcs not mapped in great detail (the great majority), exploration strategies will be brightened by the realization of the intense dynamism of arc systems and of the dominant role of strike-slip faults in this dynamism. Although the presence of even large, regional strike-slip faults may go undetected during field work, with the use of conventional aerial photographs, the supplementary use of satellite and

radar imagery may reveal great faults that were at best suspected in areas previously mapped. Placed within the network of smaller faults already revealed by conventional mapping, these great faults can define the presence of prime fault blocks. The mobility of these fault blocks in vertical motions, in rotation, in thrusting and ramping, can be assessed as a necessary accompaniment to other more usual modes of exploration.

The study of block mobility can start even before detailed fieldwork commences. Areas of alluvium and other such superficial deposits should receive particular attention, especially if the deposits appear to be linked to adjacent youthful topographic highs. Fault style and block-pattern should be established. Intrusion caps buried at shallow depths can be detected, often by their negative magnetic anomaly patterns (following on alteration), and their locations set within the established fault pattern. Sophisticated low level, high sensitivity aeromagnetic and radiometric surveys are usually appropriate (see Webster et al., 1989). An approach using mineral deposit models also has a place here (see Clark, 1986).

The general rule should be to adapt exploration tactics to the notion of extreme mobility of fault blocks and to the intensity of both vertical and rotational movements.



Tea break

Conclusions

A review such as this tends to a set of fairly simple and encouraging conclusions.

Apart from the southern third of Papua New Guinea (which is part of the Australian craton) all four countries - Papua New Guinea, Solomon Islands, Vanuatu, Fiji - are made up of mixes of arc rocks that have been produced by island arc systems building through most of the Cenozoic. The development of these arcs has been complex and attended by intra-arc spreading, by subduction reversal, by vigorous local tectonism, and in the instance of Fiji, by massive rotational movements. All of these grand tectonic movements, along with the geological development, are conducive to the emplacement of high-level intrusions that may be marked by hydrothermal, in particular epithermal, metal deposits.

All four countries have been built along an obliquely convergent boundary that has been the site of vigorous strike-slip faulting, especially during the Neogene. Lateral movements of fault blocks, and their rotation about vertical and horizontal axes have been brought about by this fault activity. The activity has been especially marked since the Miocene and has enhanced the injection of calcalkaline magmas. High level intrusions are common and include a variety of rock types. Importantly, many are andesitic or shoshonitic or, more rarely, rhyolitic. Autobrecciated versions and tectonic breccia-equivalents of these rocks are associated with the intrusive bodies; indeed, they may carry rich parts of the ore body.

The target area in Papua New Guinea is by far the largest of the four countries, and its complexity is magnified by the presence of many exotic terranes, some of which have shared in its Tertiary development, and by several collision zones.

In conjunction, these prime features amount to a convincing argument, amounting to a conclusion, that the countries possessing them have high gold potential.

The potential of the region has been confirmed by the fine discoveries over the last decade or so of large gold deposits in both porphyry copper and epithermal forms. But the potential has not been exhausted by the discoveries. Even if the number of promising prospects is doubled over the next decade, the total will still be short of the number so far found in equivalent ground in the western United States (after more than 100 years of search). Another conclusion, therefore, is that



Crater, "The Daughter", Rabaul Caldera

more discoveries will be made. None of the four countries has been adequately explored. Intensive gold search is relatively youthful, even in Papua New Guinea. The terrains are tough. The search methodology has often not been far in advance of simple prospecting.

Sophisticated search strategies and tactics will be fruitful. The model presented here, that involves greater emphasis on structural control and therefore on high grade deposits, would fit a modern approach. We believe that the region we have described is one full of promise for the motivated company with an exploration arm strong in experience, in practical exploration techniques and with a sound exploration strategy.

The Appendices show that for all four countries, government generally favors competent, cooperative and well-intentioned exploration companies. Mineral rights are vested in the state. Legislation is essentially fair and reasonable. The question of land ownership and access to lands is not a simple or easy one. But patience, goodwill, a spirit of understanding and the readiness to discuss the wishes and aims of the company with the land custodians will usually solve most of the problems that arise about the use of land.

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APPENDICES

Disclaimer: The information in this review, and especially in these appendices, is intended to give basic information of the kind often needed by persons and companies interested in mineral exploration in the Southwest Pacific. We have tried to be accurate in the gathering of this information but do not accept liability for any loss suffered as a result of any action of any kind whatsoever taken by any person or persons based on the information in this publication. In particular, the appendices are necessarily summarised and the information in them is intended as a guide to assist persons and companies to pursue matters in detail and with professional guidance.

INFRASTRUCTURE

PAPUA NEW GUINEA

Papua New Guinea is the largest of the Southwest Pacific countries, with a population of over four million. It has relatively good infrastructure compared to other developing nations. An exception is its road network, which is still in the early stages of development. Because of the ruggedness of the terrain, aircraft are the main transport vehicle.

Jackson's Airport at Port Moresby is the nation's major international facility, although there are other international airports at Kieta on Bougainville and Vanimo in West Sepik (northwestern Papua New Guinea). There is international service to Manila, Singapore, Solomon Islands, Fiji and several Australian cities. Other major airports exist at Lae, Wewak, Madang, Mt Hagen, Goroka and Rabaul, but literally hundreds of smaller airports and landing strips exist throughout the country. Air service, often using helicopters, is frequently the only method of access. Air services are available to all significant population centers, to an extent offered by few countries.

The road network consists of about 18,350 km (11,375 mi) of vehicular roads, of which only about 3 per cent are sealed. Most roads in urban areas are paved. The principal roads are around Port Moresby, from Lae to Mt Hagen and Mendi in the Highlands, from Wewak to Nuku in the Sepik, and from Kieta to Arawa and Panguna on Bougainville.

Most of the towns are on the coast and are not linked by adequate roads. There are no railroads. Major coastal cities must be supplied by coastal shipping or air. The shipping services

are efficient and comprehensive, employing approximately two hundred and forty commercial vessels, some of them containerized. International shipping lines run regular freight services to Southeast Asia, Japan, Europe, New Zealand and Australia.

Electricity is supplied by the Papua New Guinea Electricity Commission, which owns and operates power stations in 25 areas of the country. There are six major hydroelectric stations and other centers are supplied by diesel power stations. Water resources represent one of the major assets of the country. Identified hydro power potential is currently estimated at between 20,000 and 25,000 MW. Fully reticulated water supplies are provided in town centers throughout the country. Generally, the water is safe to drink in these areas.

The telecommunications system is highly developed. The internal telephone service, in many places using solar-powered microwave transmitters, is effective. Direct dialing by telephone is available for most long-distance calls within the country. Port Moresby and some of the other major urban centers also have direct dialing facilities for international calls. Facsimile, telex and postal services are available in the urban areas.

There is a variety of commercial houses, banks, light engineering and fabrication services in Port Moresby and Lae.

SOLOMON ISLANDS

Air access to Solomon Islands is through Brisbane, Australia or Nadi, Fiji (Air Pacific), or from Papua New Guinea (Air Niugini). The international airport at Honiara is being enlarged to cater for the largest jet aircraft. SOLAIR runs the internal air service.

The establishment in 1978 of Solomon Islands International Telecommunications Ltd. (SOLTEL) in 1978 has provided the country with adequate telephone, telex, telegraph and facsimile services. These services are available via the company's modern satellite communications system. There are radio links between most islands.

There are three international seaports that can accommodate large vessels with drafts to about 30 feet and that can handle containers, at Honiara on Guadalcanal, Yandina in the Russells group and Noro in New Georgia. The government and private companies operate more than 130 vessels to provide inter-island shipping services.

There are about 100 km (62 mi) of paved roads in the urban areas of

Honiara, the largest town, Gizo (New Georgia) and Auki (Malaita), and an additional 400 km (250 mi) of main roads surfaced with coral or gravel. There are more than 1300 km (800 mi) of secondary roads around major centers and agricultural areas. Mineral exploration in the interiors of the islands has to be done by helicopter or by field parties that can operate independently.

Honiara and other urban centers have a continuous supply of electricity but the rural areas are not systematically electrified. Inland locations must generate their own power. International-standard accommodations and general urban amenities are confined largely to Honiara and a few tourist locations. Rental cars are available in Honiara.

Solomon Islands does not have any support facilities directly related to mining such as analytical labs, drilling rigs, supplies. A normal range of commercial houses and light engineering services are available.

VANUATU

There are direct flights from the international airport at Port Vila to Sydney, Melbourne, Brisbane, and Fiji. Connecting flights to the United States and any other countries can be made from these destinations. Several international and local car rental firms operate in Vanuatu. There is an adequate road system on the larger, more populated islands. Most potential areas for mineral exploration will require boat or helicopter access. Field parties have to be organized well ahead and be able to operate independently. The local Geological Survey will assist with advice (see Follow-up section below). Boats are readily available but helicopters may be difficult to arrange.

Ports of entry are Pt Vila and Luganville on Santo. The deep-water wharf at Pt Vila is 228 meters (747 ft) long and can accommodate vessels with a draught of 11 meters (36 ft). The wharf at Santo can accommodate vessels of 156 meters (511 ft) with a draught of 10 meters (33 ft). Regular cargo services from Australia, Europe, New Zealand, United States and Japan are provided by a number of lines.

Comprehensive 24 hour international communications in the form of telephone, facsimile, telex and telegraphic services by satellite are provided by the Vanitel company.

Two private companies provide electricity for Pt Vila and Luganville. There is no centralized electrical distribution system for the rest of the islands. A potential mineral project would have to provide its own power.



On Survey

There are no facilities currently available for any type of sample assaying. Mineral samples would have to be sent to Australia, Fiji or Papua New Guinea for assaying. Drilling rigs would also have to be hired from one of those countries.

FIJI

Fiji is the most developed of the small Southwest Pacific island nations and has an extensive infrastructure. There are two international airports (at Suva, the capital, and Nadi on the west coast of Viti Levu) and three shipping ports (Suva, Lautoka and Levuka) that handled a combined tonnage of over four million metric tons in 1984. There is an extensive local shipping network to the smaller outlying islands.

Fiji has approximately 3,300 km (2,050 mi) of roads, one-third of which are all-weather roads. A 500 km (310 mi) highway circles Viti Levu, linking Nadi and Suva. There is an adequate supply of electricity to the more populated areas. Rural areas rely on diesel-generated power. About 70 percent of the population has access to piped water, including all urban areas.

Fiji is steadily expanding its network of postal, telephone, radio telephone and telex services in urban and rural areas. All major towns in the country have automatic exchange systems. Telephone and cable links with other countries are available through the Posts and Telecommunications Dept and Fiji International Communications Ltd. (FINTEL). There is a highly organised tourist industry. The major hotels have facilities for sending and

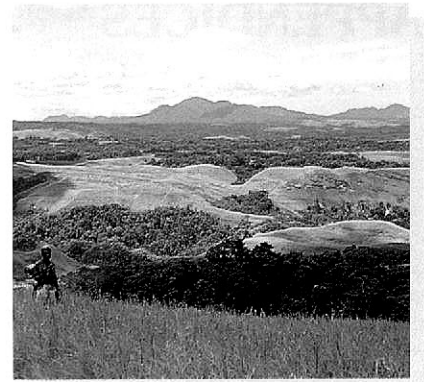
receiving facsimiles, international phone calls and telexes.

An analytical laboratory at present in Fiji can handle sample preparation and assay work. The laboratory has a complete line of more advanced services available by shipping or by airlifting mineral samples to its facilities in Australia.

Several drilling companies are located in Suva and can provide diamond and reverse circulation drilling services in Fiji as well as the rest of the Southwest Pacific nations. Engineering and fabrication services are available.



Active fault scarp



Uplifted reef terraces, Honiara foothills, from Mt Austen

LAND ACQUISITION: DIFFICULTIES AND PROCEDURES

Land acquisition problems are similar for Papua New Guinea, Solomon Islands, Vanuatu and Fiji. What follows here (and see Stubbs, 1987) is a generalized guide to the manner of dealing with such problems, and their nature.

Those mining and exploration companies who wish to explore and mine in Papua New Guinea, Solomon Islands, Vanuatu and Fiji will encounter difficult problems in gaining access to land if the proper approach and procedures are not followed. Rights to land are governed by traditional, pre-colonial communal law as well as by legislation. These rights are now guaranteed by the national constitutions of all four countries. Resource development enterprises in particular will have to come to terms with traditional landholding customs that govern the ownership and right to the use of most land. The concept and rights of private land ownership are not part of most land tenure systems.

The Islanders do not perceive land as a commodity that can be bought and sold to individuals. Instead, land is a permanent and integral part of a village or clan community that can never be alienated. The present occupants of the land believe that the land is for their temporary usage for agriculture, hunting and fishing. They feel it is their duty to hold the land from their ancestors in custody for their descendants.

Foreign investors who wish to acquire land, in this case for mineral development, will find that they need to lease but not buy the land. Often, the national government will acquire the land and then lease it to the enterprise desiring its use. The role of government is normally to ensure that traditional rights are properly respected. Governments may not take the role of negotiator except in large projects of

national importance. In previous instances of large or medium scale mining, governments have tended to do just this.

During negotiations, the following problems are likely to emerge:

1. Identifying the custom landowners. There is an effective land registration system in Fiji, but not in most of Papua New Guinea, Solomon Islands and Vanuatu. In these three countries, title to land is something that is carried in the memories of the owners and their neighbors. Although areas are defined by land forms and particular

to sit down, to listen to the owners, to talk and explain.

3. Conflicting rights. There may be rights or claims to an area that are separate from the land rights. One community may control an area and be utilizing it for agriculture. Others may be using part of the same area for grazing or hunting. If the controlling community agrees to lease the land for purposes that interfere with the rights of the hunters, a conflict could occur that might eventually cancel a previous agreement.

Procedures

Obtaining access to custom lands is indeed a problem but not an insurmountable one. The primary point is that the problem exists and has to be approached on a serious basis. Local sensibilities and perceptions regarding land have to be acknowledged and carefully considered. Failure to do so will result in the breakdown in relations between the foreign developer and the local population, and a guarantee of failure in negotiating development rights.

There are many opinions on the type of offer to make for the use of custom land. In all circumstances, however, local knowledge and expertise is an essential element for conducting any negotiation. A local person with this knowledge and with patience and negotiating skills is an essential component of doing business.

Although the land situation is a major problem, many mineral development projects have been undertaken in Papua New Guinea and Fiji and these issues on the whole have been resolved successfully. It should also be remembered that as time has passed commercial thinking may change. Government support will expedite efforts to procure possible government help in finalizing mutual agreements.



Security – 1930s style, Mt Kasi, Fiji

features and their use generally agreed upon, disagreements about boundary and usage can arise.

2. Negotiating with traditional owners. Generally speaking, no individual has any right to dispose of any interest in traditional land. Land belongs to a community as a whole. Each community is a democracy in the sense that any decision has to be discussed and agreed upon by everyone. Decision implies discussion. The nature and the effects of the proposed project must be clearly explained to, and understood by, the traditional owners. Semi-subsistence agricultural and marine activities are the principal means of livelihood for most Pacific islanders. Those people with a subsistence-based life experience may not appreciate the benefits promised them.

Patience is an absolute necessity for these negotiations, and also a readiness

LEGISLATIVE ASPECTS

This section is intended as a guide to those legislative aspects likely to interest the mineral explorer. But it is only a guide and not in any way a substitute for a serious study of the legislation relevant to the time and place.

PAPUA NEW GUINEA

LAWS AFFECTING MINERAL EXPLORATION/DEVELOPMENT

Papua New Guinea is a parliamentary democracy, with a single house. The law of Papua New Guinea is the constitution which came into force in 1975 following on the gaining of independence. The legal system is based on the English legal system. Also included is "custom" or traditional law. As already said, this law is the cultural, village-based system, of pre-unification Papua New Guinea; it impacts on foreign investors in the area of land tenure and in mining activities. Mineral rights are vested in the state. Some of the legislation affecting mineral exploration and development is listed:

The Mining Act, Chapter 195: The current mining law is based on this Act, which was adopted in 1978. At present, the Act is under review by the Department of Minerals and Energy. Existing mining policy was formulated to encourage development of the country's resources on terms and conditions which secure maximum benefits for the nation and give an appropriate return to investors.

Land Act, Chapter 185: Usually, leases issued under the Mining Act are sufficient for mining operations. However, if infrastructure is to be constructed that will remain after the life of the mining operation, a company may make application for a State Lease. Usually the State will decide if such a lease is necessary and this will occur between the pre-feasibility and the end of the feasibility study.

If a State Lease is required, the company is subject to a rent payment. It is usually 5 per cent of the unimproved value of the land. This can be lowered or waived by the Minister after he has considered a report from the Land Board.

National Investment and Development Authority (NIDA)

NIDA is responsible for coordinating the implementation of government policies on foreign investment. All foreign-controlled companies must register with the Authority. For initial exploration purposes, however, a company need only notify NIDA of its

presence rather than make an application for status. Exploration drilling is not exempt and for this, status is required.

Once a project is in the development stages, it is necessary to register with NIDA. This involves a detailed project study. In large scale projects, exemptions can be obtained from NIDA for sub-contractors.

Companies Act, Chapter 146:

All domestic and foreign corporations doing business in Papua New Guinea must register with the Registrar of Companies. A Papua New Guinea company must have one resident director and a resident secretary. A foreign company must have a resident agent. While exploration activities can be undertaken by either resident or non-resident corporations, the case is much different once the development stage is reached.

Central Banking Act, Chapter 138:

The Foreign Exchange regulations issued pursuant to this Act outline the treatment of such things as the monetary control provisions, borrowings, insurance and dispatch of securities, and proceeds of export. All inward and outward transactions are monitored by the Bank of New Guinea. Most corporations must maintain a ratio of long-term debt to equity of 3:1 when obtaining overseas loans.

EXPLORATION AND MINING LICENSES

The licence requirements for mineral exploration and mining were initially defined in the 1978 Mining Act, Chapter 195.

Licences Required:

The mineral exploration permit required by the Papua New Guinea government is a Prospecting Authority (PA). Actual mining will require a Special Mining Lease (SML).

Prospecting Authority details and Requirements

Maximum size: 2500 sq km (975 sq mi) per PA. Period of licence: two years, renewable at end of period, but 50 per cent of total area must be relinquished unless area is 250 sq km (97.5 sq mi) or less.

Costs: Application/Rental Fees

(1) Application fee of K2,500 (US \$2,875) per PA.

(2) Security deposit of K1,000-K1500 (US \$1,150-1,725) per PA (refundable).

(3) Annual government rental of 50 toea (US \$.57) per sq km must be paid in advance.

(4) Access fees and damage compensation must be negotiated with custom landowners in area of PA.

Costs: Work Program and Expenditure Requirements

- K100 (US \$115) per sq km per annum for the first 2 years.

- K200 (US \$230) per sq km per annum for the second 2 years

- K500 (US \$575) per sq km per annum for subsequent renewals.

- K5000 (US \$5,750) in first 2 years for PA smaller than 50 sq km.

Acceptable Expenditures:

(1) Those directly connected with acquisition and interpretation of exploration data, including laboratory work and feasibility studies.

(2) Depreciation of equipment if items are used specifically in connection with exploration of the PA.

(3) Overheads and administration not to exceed 15 per cent of total expenditure.

Unacceptable Expenditures:

(1) PA fees and legal costs.

(2) Real estate (land, office, housing, etc).

(3) Research considered to be proprietary information.

Financial Requirements:

Applicants must provide the Mining Advisory Board with information on the company's financial status.

A Shareholders' Annual Report is acceptable. Such information must also be provided annually.

Joint Ventures:

Generally, new partners are not allowed to enter into PA exploration during the first two-year term. This is usually not a problem in subsequent terms after PA renewal. However, if "special circumstances" can be demonstrated and a net increase in exploration expenditure will result, then a Joint Venture in the initial term may be allowed.

Reporting Requirements:

The following are required—

(1) Biannual prospecting reports

(2) Biannual expenditure statements

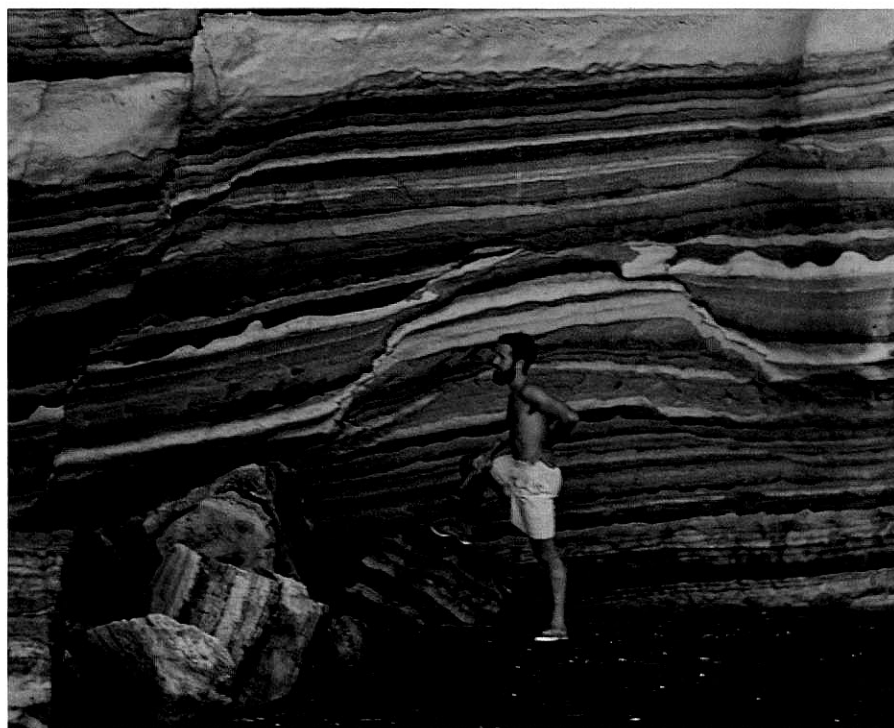
(3) Annual reports giving comprehensive details of all work done in relation to the PA.

(4) Relinquishment reports giving summary data on any land in the PA that is relinquished, due to unfavorable geological data or to the 50 per cent that must be given up at the end of the PA term.

(5) Final report at the expiration of the PA giving a comprehensive summary of all work conducted in relation to the PA since grant. Such reports should relate exploration procedures adopted and conclusions reached.

Prospecting Authority conditions may include the following:

"A right is reserved for any person authorized under this Act to enter and



Turbidites, Choiseul

prospect for alluvial gold within the area of this Authority, and to apply for and be granted Claims to mine alluvial gold within that area." Section 30 (D) (ii) (A) (B).

In effect, this gives the local landholders the opportunity to exploit any alluvial deposits that may be found on the PA. The government feels that alluvial gold belongs to the indigenous population regardless of the fact that a company may have exploration rights in the area.

Special Mining Lease - Details and Requirements.

Area of Special Mining Lease: A special mining lease may be granted over an area not exceeding 60 sq km.

Term of Special Mining Lease: A special mining lease may be granted for any period up to 42 years. Further renewal periods of up to 21 years may be granted.

Rehabilitation: The Minister may require the lessee to carry out such works as are specified by the Minister to rehabilitate any land damaged during the course of mining.

Rent: Rent on a special mining lease shall be as determined the Head of State, acting on advice, and specified in the lease, subject to review at intervals of 21 years.

Assignment: The lease may not be transferred, sublet, mortgaged or charged without the written consent of the Minister.

Nonfulfillment of Conditions: If any rents, royalties or occupation fees are not paid by the due date, or any covenant or condition is not performed or observed, the Minister may require full performance or payment within a specified time. Failure to comply may result in the Minister forfeiting, or cancelling the lease.

Surrender of Lease: If the lessee has paid all rent, royalties and occupation fees, he may, with the consent of the Minister, surrender the entire lease or any part of the land comprised in the lease.

TAXES

There are a number of tax provisions which affect the potential minerals project developer in Papua New Guinea. Among these are royalty tax, corporate income tax, additional profits tax and a dividend withholding tax.

Royalty Tax

Royalties are paid to the Government of Papua New Guinea. The Mining Act imposes a State Royalty

of 1.25 per cent of f.o.b. revenue or net smelter returns. The government then distributes a part of these funds (currently 20 per cent) to the local government in the area where the mining takes place. Royalty payments are deductible expenses for the purposes of computing taxable income. No separate royalty agreement has to be negotiated with the custom landowners. But access fees and compensation for loss of land use will have to be negotiated with these owners.

The current Mining Act, Chapter 195, Section 105 is the legal basis for this royalty.

Corporate Income Tax

The income tax is levied by the national government alone, and was legislated in the Income Tax Act. The rate is 35 per cent of taxable income for resident companies and 48 per cent for non-resident companies. Only the 35 per cent rate will apply, because the Special Mining Licence needed to begin a project is granted only to a resident company. Although a Prospecting Authority may be held by a non-resident company, conversion of this license to a mining license requires that the company register and incorporate in Papua New Guinea.

Deductions allowed in calculating taxable income from mineral product revenues include operating expenses, interest charges, previous tax losses and depreciation of plant, equipment, mine development and exploration costs.

Depreciation Provisions

Depreciation expenses have been developed to assist the developer during the early years after project start-up. The Act distinguishes between several categories of mining capital expenditures and defines the maximum allowable rate for each. The three major categories are: exploration expenditures, mine development expenditures, and expenditure on plant capacity after commencement of production. For example, the maximum allowable exploration expenditure depreciation deduction is the total exploration expenditure divided by: (1) five, or (2) the remaining years of mine life, whichever is less. Exploration expenditure from a surrendered licence is depreciable at the same rate provided the depreciation claim is made within 11 years of surrendering the aborted licence.

The Act also contains provisions to increase the depreciation claim above the standard claim if mine profitability is low during the critical early years of development. The taxpayer may also elect that none of the previous

provisions apply for assets with estimated life of less than fifteen years. The taxpayer can apply to the Taxation Officer and specify the desired depreciation rate. The intent of this provision is to allow adequate tax depreciation of short life assets such as motor vehicles. Losses can be carried forward for up to seven years but cannot be carried back. A loss arises whenever gross revenue, minus the sum of royalties, operating costs and interest payments, is negative.



Fringing Reef, Bougainville

Additional Profits Tax

The government recognizes that the mining industry is not any more profitable than most industries over the long term. In periods of very high profitability, however, the State, as owner of the resource, seeks a share in the windfall gains.

The Additional Profits Tax (APT) does not impose a ceiling on profits. Rather, the regime attempts to ensure a reasonable sharing of revenues during period of very high profitability.

To activate the APT, the taxpayer must achieve an after-tax rate of return of 20 per cent on investment. APT taxes are incurred on an after-Corporate Income Tax cash flow. APT cash flow is defined as gross revenues less operating costs, royalties, exploration and development expenditure, interest before production start-up, all investment after start-up, and Corporate Income Tax. APT liability is defined as the cumulative APT cash flow of the previous year multiplied by 120 per cent plus the current year cash flow. The taxpayer can elect that the cumulative rate be the U.S. prime rate plus 12 per cent.

As long as the APT liability remains negative, no APT taxes are incurred. This means effectively that no APT taxes are payable before achieving an after tax 20 per cent rate of return. When APT liability becomes zero, the tax is incurred at a 35 per cent rate on APT cash flow.

It should be noted that the APT applies to projects under Special Mining Leases after the end of the Investment Recovery Period. A negative cash flow in a subsequent year would take the operation out of the APT position. It would not be payable until APT liability became positive again. The tax is balanced to avoid any additional burden on what are genuinely marginal projects, to protect the investor against unexpected changes in international costs of financial capital, and to protect the international value of the cash flows receivable, against exchange rates prior to liability for APT.

The calculation of the APT liability also incorporates an exchange rate adjustment.

Dividend Withholding Tax

Dividends which are paid to shareholders out of retained earnings, after corporate income tax and APT, are subject to a dividend withholding tax of 17 per cent. Distributions by a Papua New Guinea branch of a non-resident company are not subject to the tax.

GOVERNMENT EQUITY

The Papua New Guinea Government has a policy of reserving the right to take up to a maximum of a 30 per cent participating equity interest, at cost, in major mineral projects in the country. The government has yet to take the maximum equity. To date,

government equity interest in four major projects has been as follows: Bougainville (20.2%), OK Tedi (20%), Misima (20%), and Porgera (10%). The terms of participation are negotiated separately in each case.

SOLOMON ISLANDS

Solomon Islands is a parliamentary democracy. Independence from Great Britain was achieved in 1978. The executive arm of the government is the National Cabinet headed by the Prime Minister who chooses his ministers, limited to 15 including the Prime Minister. The legislature is a single-chamber National Parliament composed of 38 elected members. The normal life of the parliament terms is four years.

In 1981 the central government created seven provincial governments with the purpose of decentralizing the national government process and increasing responsibility at the local level. These local elected councils operate a wide range of facilities including communications, rural health services and schools. Funding for these activities is provided by the central government in Honiara.

Some of the legislation affecting mining exploration and development is listed:

The Mining Act

The current mining law is based on this act, which was adopted in 1979.

In 1988, a new bill, Mines and Minerals Bill, was proposed which is currently being considered by the Ministry of Lands, Energy and Natural Resources. The employment and future

training of Solomon Islanders is a consideration of this legislation. Under the present Act, mineral rights are vested in the state.

Foreign Investment Act

Foreign companies are required to be registered under the Foreign Investment Act of 1979. Foreign companies permitted to conduct business in Solomon Islands are also required to advise the Foreign Investment Advisory Committee of any proposed variations in the nature of its activities and the reasons for the proposed variations.

Land and Titles Ordinance

Nearly 90 per cent of land in Solomon Islands is customary land. By law, non-citizens may not own or use this land. Before a mining operation can begin, the land has to be registered in accordance with the rules defined in the 1963 Land and Titles Ordinance 1959. The land can then be leased for periods of no longer than 75 years.

EXPLORATION AND MINING LICENSES

The current Mining Ordinance contains legislation that defines the following types of licences:

- 1) Prospector's Right
- 2) Reconnaissance Permit
- 3) Prospecting Licence
- 4) Special Prospecting Licence
- 5) Alluvial Miner's Permit (only for individuals who are citizens of Solomon Islands)

- 6) Mining Leases
- 7) Special Mining Leases

The proposed Mines and Minerals Bill reduces and simplifies the number of licences to the following:

- 1) Reconnaissance Permit
- 2) Prospecting Licence
- 3) Alluvial Miner's Permit (Solomon Islands citizens only)
- 4) Mining Lease

Currently, all companies conducting exploration in the Solomon Islands have a Special Prospecting Licence (SPL).

Reconnaissance Permit—

This Permit may be granted over an area not less than 40 square miles and for a period not exceeding six months and may not be renewed except with the approval of the Minister. This permit is not transferable and is valid for the prospecting for all minerals for which prospecting is prohibited or restricted by the Minister. The holder of the Permit has the exclusive right to prospect for the minerals on the land the subject of the permit. The holder



Pillow lava, Viti Levu

is, moreover, subject to the provisions of the Ordinance, entitled to a Prospecting Licence in respect of an area not exceeding 5000 acres within the area of the Permit.

Prospecting Licence—

This license may be granted over an area not exceeding 1000 acres to prospect for such minerals as specified in the licence. The total area held may not exceed 5000 acres. The license may be granted for such period and may be extended and renewed for such periods as determined by the Director subject to the proviso that the aggregate period (whether or not continuous) for which the holder may prospect on any area of land does not exceed four years.

Special Prospecting Licence—

Under the terms of the Ordinance the Permanent Secretary, Natural Resources, may, subject to the approval of the Minister, grant Special Prospecting Licences upon such terms and conditions, whether in accordance with the provisions of the Ordinance or not, as the Minister may think fit. A special license may not, however, be granted in respect of an area less than five square miles unless either the applicant has held a Prospecting Licence over that area for four years or there are exceptional circumstances.

An application for a special Prospecting Licence must be accompanied by:

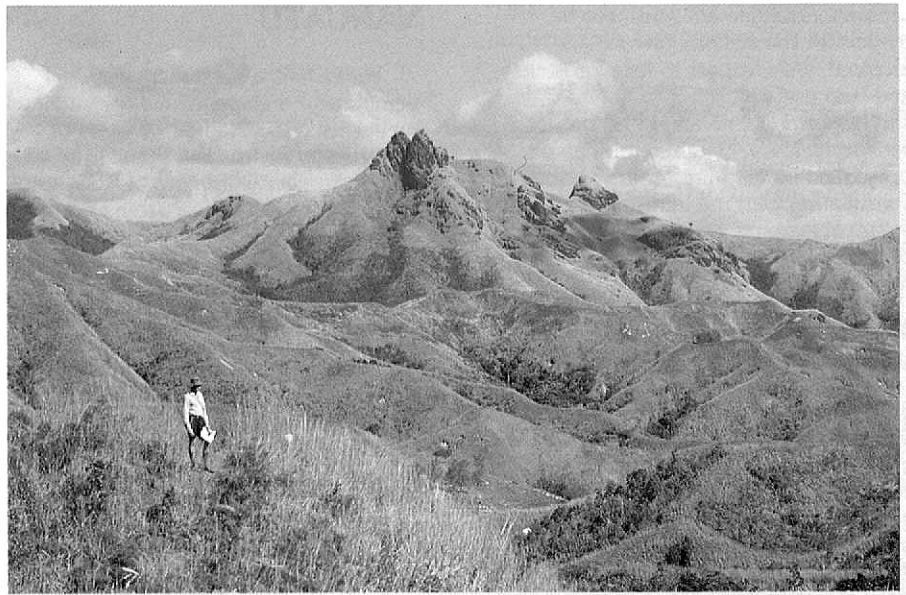
(a) a statement of the approximate number of workmen the applicant guarantees to employ or continuous prospecting during the currency of the license, and

(b) a programme of prospecting work which the applicant undertakes to perform on the area applied for and an estimate of the expenditure to be incurred in such work.

A special Prospecting Licence is subject to the provisions relating to a Prospecting Licence save where these vary with any special terms and conditions of the Special Licence.

Alluvial Miner's Permit—

Alluvial Miner's Permit may be granted by the Permanent Secretary, Natural Resources, or an authorized officer, to Solomon Islands citizens. This permit is not transferable and remains in force for one year from the date of the grant and may be renewed for periods of one year each. The permit entitles the holder to prospect and mine for such minerals in the bed of such river or water-course and within such distance from the same not exceeding 100 feet.



Plug in Wainimala Group

Permit to Mine—

A permit to mine is granted for a period not exceeding two years from the date of the grant and may be renewed for periods not exceeding one year each. The area over which the permit is granted may not, except with the approval of the Minister exceed 100 acres for precious minerals.

Mining Leases—

The lease may be granted for such a term being not less than five nor more than 21 years as the Minister may think fit. At the expiration of the term originally granted or of any renewal of the term the holder of a Mining Lease who conducts his mining operations in a normal and businesslike manner is entitled to renewal of the lease for a further term not exceeding 21 years upon the conditions which are then generally applicable to new Mining Leases. The area over which a Mining Lease is granted may not, except with the prior approval of the Minister, exceed 100 acres for precious minerals.

Special Mining Lease—

The Director may with the approval of the Minister grant a Special Mining Lease upon such terms and conditions whether in accordance with the provisions of the Ordinance or not as the Minister may think fit. The provisions of the Ordinance relating to Mining Leases apply to all Special Mining Leases except where these vary with the terms and conditions for the Special Lease.

TAXES

The main tax on corporations is income tax and applies to all entities that fall within the meaning of the word "company" unless for some specific reason either the party or the income is exempt from tax. A company incorporated in Solomon Islands is a resident of the islands for income tax purposes. A corporation not incorporated in Solomon Islands is considered to be a resident if it carries on business in Solomon Islands and if either its central management and control are there or its voting power is controlled by residents of Solomon Islands.

In general, companies incorporated in Solomon Islands are taxed at the rate of 35 per cent on chargeable income and companies not locally incorporated are taxed at the rate of 50 per cent. Tax relief is usually of major concern to potential investors, and local legislation provides for the granting of tax holidays to pioneer companies or the immediate write-off of the cost of depreciable assets when the investment is likely to provide significant benefits to the economy. Such perceived benefits include export contribution, net import substitution, increased employment and development of rural areas.

Royalty Tax

Section 76 of the current Mining Ordinance deals with royalties. The Minister of Natural Resources is given power to defer royalty payments. Under the proposed Mines and Minerals Bill, royalties are payable to the Government, who will be responsible for distributing a portion of the royalty to the custom landowners. However, a

separate arrangement must also be made with the custom landowners involved, with respect to fees for access and land use.

Importantly, royalty rates are not set specifically. The rate may be prescribed by the Minister in consultation with the Minister of Finance, keeping in mind the principle of fair market value of the mineral at the place of mining.

Tax Incentives - Capital Investment

There are various special rates of depreciation available for certain industries. The most notable is the 100 per cent depreciation that may be claimed on capital expenditure in the year of incurring the expenditure for the purchase of those assets that may be declared "special development assets" by the Minister of Finance. There are no restrictions on the types of businesses that are eligible to apply for classification as "special development activities."

Tax Concessions for New Industries

A company may apply for pioneer company status and, if successful, acquire the benefits of a tax holiday whereby the total income of the company is exempt from tax for the period of the holiday. The amount of income so exempted shall not exceed the ordinary issued share capital of the company. In considering applications for tax holidays, the Minister will take into account the economic and other benefits likely to accrue to the Solomon Islands. The extent and nature of concessions given to investors by the Government are based on assessments made during the project evaluation basis. In all cases, concessions are discretionary and must be specifically requested at the proposal stage. Various financial incentives may be offered, including import and export duty reductions and tariff protection.

GOVERNMENT EQUITY

Currently, the country has no mines and no precedent exists to indicate government's expectation. Equity is likely to be negotiated prior to mine development.

VANUATU

Vanuatu is a parliamentary democracy. Independence was attained on July 30, 1980, after 74 years of joint rule by Britain and France. A single chamber legislature of 46 members is elected every four years. It consists of a Council of Ministers, headed by the Prime Minister and a Cabinet. The last elections were in 1987. The Prime Minister is elected by parliament from a secret ballot from its members. The Head of State is a President, elected for five-year terms by an electoral college of Parliament. The Constitution provides for a National Council of Chiefs who advise Parliament on matters relating to custom and tradition. Aspects of legislation affecting mineral exploration and development are given here.



Alluvials, Mt Kare.

The Mines and Mineral Act

The current mining law is based on this act which was adopted in 1986. Under the act, mineral rights are vested in the state. The administrative control over mineral resources is the Department of Geology, Mines and Rural Water Supply.

EXPLORATION AND MINING LICENSES

The licences requirements for mineral exploration and mining are defined in the Mines and Mineral Act, no.11, 1986.

Licences required by the Vanuatu Government are prospecting permits, prospecting licences and mining licences.

Prospecting Permits—

Prospecting permits are issued to allow preliminary prospecting activities needed to identify areas for further exploration activity. These permits are good for 12 months. A fee must be paid through the Commissioner or Minister. Activities are restricted to those areas not already covered by a prospecting licence or mining licence. Only properly registered companies or indigenous citizens of Vanuatu may receive prospecting permits.

Prospecting Licences—

Prospecting Licences are granted over areas not exceeding 100 square km. Prospecting licence are not granted to an applicant unless the Minister is satisfied that:

(a) The applicant has adequate resources, technical competence and experience to carry on effective prospecting operations.

(b) The program of prospecting work to be fulfilled is adequate.

(c) The proposals for the employment and training of citizens of Vanuatu are adequate.

Prospecting licences can be issued for any length of time up to three years. At the end of this period, 50 per cent of the area covered in the licence must be relinquished unless the prospecting licence is changed to a mining licence. The prospecting licence may be renewed twice. Although not written in the statutes, the government usually expects drilling by the fourth year.

Work Requirements—

A work program, including expenditures, must be agreed upon before the prospecting licence is issued. This is negotiated with the Minister or the Commissioner and periodically reviewed.

Mining Licences—

A Mining Licence application must contain the same information as previously listed for a Prospecting Licence. As well, details of the mineral deposit, mining and treatment plan, mining operations, forecast capital investment, employment, goods and services, and environment reclamation are needed.

TAXES

Vanuatu is a tax haven. There are no personal or company income taxes, no capital gains or profit taxes, no death or estate duties, no exchange controls or tax treaties (such as double taxation agreements). This tax free status has led to the establishment of an international finance center in Pt Vila.

More than 500 offshore companies have taken advantage of Vanuatu's financial status. There is a growing international shipping registry through Vanuatu's offices in New York. This is a natural extension of Finance Center activities. The registration rates for shipping are comparable to those in Panama and Liberia.

Royalty -

Vanuatu currently has no set royalty schedule on mineral projects. There are no producing mines of any type, therefore no recent precedent exists to indicate the government's expectations.

Royalties would be paid to the Republic of Vanuatu. The government would be responsible for allocating a portion of the royalty paid to the custom landowners of the area where the mining occurs.

EQUITY

Currently the country has no gold mines and no precedent exists to indicate government's expectation. Equity is likely to be negotiated prior to mine development



Turbidite, Malekula

FIJI

The law of Fiji is the constitution. A new constitution was adopted in 1990 as a result of military coups in 1987. Fiji's form of state is an interim presidential system with a legal system based on the English legal system.

Legislation affecting mineral exploration and development is listed:

The Mining Act.

The controlling legislation of mining/mineral exploration in Fiji is the Mining Act (Cap. 146) passed in 1966. Mineral rights are vested in the state. Amendments have been made as needed. The administrative control over mineral resources is the responsibility of the Director of Mineral Development in his capacity as Director of Mines, subject to overall policy control by the Minister for Lands, Energy and Mineral Resources. Existing mining policy has been formulated so as to encourage development of the country's resources.

The Company Act.

All domestic and foreign companies doing business in the country must register with the Companies Office, either as a Fijian identity or as an incorporated overseas subsidiary.

EXPLORATION AND MINING LICENSES

The licence requirements for mineral exploration are defined in the Mining Act. Licences required include:

Prospector's Right:—

The right to carry out preliminary searches for minerals is granted under a prospector's right. This may only be granted to an individual but such individual may be nominated as acting on behalf of a company or partnership. The permits are good for one year and can be renewed.

Prospecting Licence:—

Exclusive prospecting rights may be granted to the holders of prospector's rights under a prospecting licence. These may not exceed 400 hectares (988 acres). Any number of licences may be held but the total area must not exceed 1200 hectares (2966 acres).

Special Prospecting Licence:—

With the approval of the Minister a special prospecting licence may be issued for areas larger than 1200 hectares. Most of the licences currently in effect are of this type. Licences may be granted for periods of up to five years and extensions may be granted. For either type of licence a work program must be presented to the

Director outlining the expected expenditures and prospecting program.

Permit to Mine:—

The holder of a prospector's right or prospecting licence may mark out an area and apply to the Director for a permit to mine. The duration of the permit is two years and thereafter may be extended for one-year periods. If the Director determines that the mineral-bearing qualities of the land warrant a lease, he may cancel the permit and require the holder to obtain a lease.

Mining Lease:—

A mining lease may be granted for a period of not less than five years and no more than 21 years. It may be renewed for an additional 21 years. The maximum area of leases for precious metals is 45 hectares (112 acres) and for other minerals the maximum area is 145 hectares (358 acres). The minister may approve the issuance of licences for larger areas. Holders of mining tenements may obtain other rights necessary for mining operations, such as water rights, special site rights and road access licences.

ANNUAL FEES & RENTS

(a) -The following annual fees shall be payable by the holder of a prospecting licence in respect of each such licence held by him:

(i) For the first 200 hectares (494 acres) or part thereof - twenty dollars (US \$12.00) for each 40 hectares (98.8 acres) or part thereof;

(ii) For each additional 40 hectares or part thereof in excess of 200 hectares - ten dollars (US \$6.00);

Provided that in the case of a prospecting licence granted or extended for a period not exceeding 6 months, half only of the above mentioned fees shall be payable;

(b) -The following annual rents shall be payable:

(i) By the holder of a permit to mine or mining lease, in respect of each such permit or lease held by him—one hundred dollars (US \$60) per hectare (2.47 acres) or part thereof: Provided that the minimum annual rent payable in respect of each such permit or lease shall be three hundred dollars;

(ii) By the holder of a special right or road access licence, in respect of each such right or licence held by him—two hundred and fifty dollars (US \$150).

The filing application fee for a mining tenement is fifty dollars (US \$30).

TAXES

There are a number of tax provisions which affect the potential minerals project developer in Fiji. Among these are royalty tax, corporate income tax, personal tax and dividend tax.

Royalty

Any royalties or proceeds received by the state in respect of any minerals extracted from any land or from the seabed are payable to the owner of the surface of that land. Rates were prescribed in the 1966 Mining Ordinance, Regulations 6 and 7. These rates are based on either a percentage of gross value (NSR) or a yield basis (net profits).

Regulation 6:—Five per cent of their value (unless otherwise determined by the Director with approval of the Governor-in-Council)

Regulation 7: (1) Notwithstanding



Fault-controlled fringing reef

the provisions of the preceding regulation, in cases where the holder of any mining tenement or tenement keeps books of account to the satisfaction of the Director, the Director may permit such holder to pay royalties on all minerals extracted from all his tenements, including those subsequently granted, on a yield basis, calculated as follows:

(a) Where the yield expressed as a percentage of the annual sale value does not exceed 20 per cent, royalty shall be at the rate of 10 per cent of the yield.

(b) Where the yield expressed as a percentage of the annual sale value exceeds 20 per cent, royalty shall be at the rate of 10 per cent of the yield, together with an additional one-fifth of one per cent (0.02 per cent) of the yield for each one per cent by which the yield

expressed as such per cent exceeds 20 per cent.

Costs: Application/Rental fees

The following fees apply with regard to prospecting licenses and mining leases. These fees are from the Mining (Amendment) Regulations, 1988 that came into effect on February 1, 1988. These new fees replace those formerly prescribed in Regulation 5 of the Mining Regulations. They are as follows:

Corporate Income Tax

A mineral exploration/development company doing business in Fiji must register with the Companies Office, either as a Fijian identity or as an incorporated overseas subsidiary. In either case, income taxes will apply at a resident company rate (37.5 per cent), which is less than the non-resident company rate (45 per cent). There is currently no additional tax on "excess profits."

There are three concessions for the mining industry in the Income Tax Act:

1) Where a taxpayer holds a valid prospecting license, he may write off against his total income from all sources such amount of his expenditure on prospecting for minerals as the Commissioner of Inland Revenue may allow.

2) As an alternative to normal depreciation, a taxpayer engaged in mining, who has incurred certain specified expenditure, may in any five out of the first eight or last eight years of a nine-year period, commencing with the year in which the expenditure was incurred, write off one-fifth of such expenditure against his total income. The expenditure specified is as follows:

a) Capital expenditure incurred in the development of mines and the extraction, treatment, refinement and sale of minerals therefrom; and

b) Expenditure incurred in the acquisition of any mining lease or tenement.

c) The Minister of Finance, where he is satisfied that it is desirable for the economic development of Fiji, may direct that the income of any mining company shall be either exempt from tax or taxed at a reduced rate.

There is a provision for carrying forward losses and there is a five year tax relief for new industries.

Personal Tax

Individuals are liable for a base tax of 2.5 per cent on gross income. Then a sliding scale goes into effect on chargeable income, i.e., total income less personal allowances. This normal tax starts at five per cent and reaches a maximum of 50 percent on incomes over Fiji \$20,000 (US \$12,000).

Dividend tax

A dividend withholding tax of 15 per cent is payable on dividends paid by a Fiji company to a non-resident, and five per cent if the dividend is paid to a resident.

GOVERNMENT EQUITY

The country has no policy of reserving the right to take up equity. In particular cases, however, the government may take equity, depending on the project.

FOLLOW-UP INFORMATION

The Departments of Geology and Mines, or Geological Surveys, within Papua New Guinea, Solomon Islands, Vanuatu and Fiji, are responsible for the collection and distribution of data on geology, exploration and mining activities for their respective countries. A detailed list of all open file company reports, geological reports, bulletins and maps are readily available upon request. Geological survey reports, maps, and copies of mineral and mining acts are available for sale. As well, current mining/exploration tenement maps and open-file company reports are available at cost of reproduction. The Geological Surveys will usually assist with advice but are not able to help directly with employees or materials.

Addresses for the respective countries are as follows:

Papua New Guinea —

Chief Government Geologist
Department of Minerals and Energy
P.O. Box 778
PORT MORESBY, Papua New Guinea
Phone: 675 21 2422
Telex: NE23305
Fax: 675 22 4222

Solomon Islands

The Geological Survey is part of the Ministry of Lands, to be contacted through the Director:
Director
Ministry of Lands, Energy & Natural Resources
Box G24
HONIARA, Solomon Islands
Phone: 677 2 2944
Telex: SOLNAT HQ66306
Fax: 677 1 1245

Vanuatu

Director
Department of Geology, Mines
and Rural Water Supply
Private Mail Bag 1
PORT VILA
Phone: 678 2213/ 2423
Telex: VANGOV 1040

Fiji

Director
Mineral Resources Department
Private Mail Bag
SUVA Fiji
Phone: 679 38 1611
Telex: 2330 SOPACPRO FJ
FAX 679 37 0039

Further Reading - References

The volume of literature covering the geology and mineral resources of the four countries is enormous. We present here, in a fairly arbitrary selection, a list of works that includes prime references that cover large aspects and areas, e.g. Hughes, 1990 (just to hand); also less embracing references that give the basic facts relating to a particular feature, and/or present an unusual and interesting aspect of a feature, and/or contain important further references.

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